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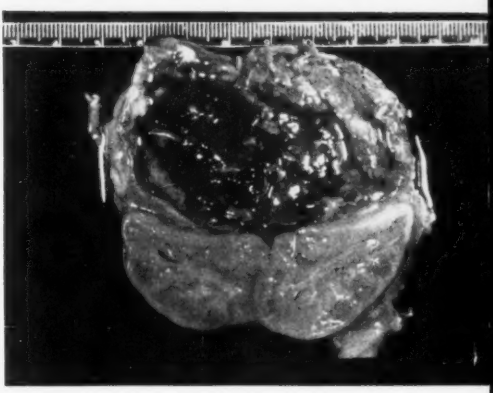

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A.M.A. Archives OF SURGERY

Anatomy of the Pancreas

A Study with Special Reference to the Duct System

WILLIAM P. KLEITSCH, M.D., Omaha

The anatomy of the pancreatic duct system has been the subject of numerous studies since the first published account by Wirsung (Fig. 1). This original and inaccurate report was later modified by Santorini to approximate more closely the arrangement found in human beings. Although studies of the pancreatic ducts continued, descriptions varied, largely because of the difficulty of demonstrating the exact relations of the ducts. When Opie popularized the common channel theory of pancreatitis, he lent an impetus to the efforts of anatomists and surgeons to demonstrate more clearly the finer anatomy of the duct arrangement at the ampulla of Vater and in the pancreatic head.

It was not the object of this study to repeat the excellent observations made by Opie and his successors concerning the detailed anatomy of the ampulla of Vater; it was rather our effort to demonstrate the exact course of the pancreatic ducts through the gland and their possible variants. It is possible to do this by means of injected and cleared specimens; consequently, for the first time the anatomy of the pancreatic duct system becomes available for demonstration. As a result of these demonstrations, it is obvious that the terms "duct of Wirsung" and "duct of Santorini" can not be used in a discussion of the exact anatomy of the pancreatic duct system. In the ensuing discussion, the duct system of the pancreas is described using four points of reference: (1) the papilla of Vater (opening of choledochus), (2) the accessory papilla (always orad to the papilla of Vater), (3) the main pancreatic duct (the large duct coursing through the body of the gland), and (4) the accessory pancreatic duct (the smaller duct of the pancreas).

Submitted for publication May 19, 1955.

From the Surgical Services of the Veterans Administration Hospital and the Creighton University School of Medicine.

METHOD

The glands dissected in this study were obtained from routine autopsies by excising the entire pancreaticoduodenal complex, which was then fixed in formalin, after which the pancreatic duct system was dissected out by gross dissection, utilizing the dissecting microscope when necessary. Fifteen glands were dissected in this manner, after which the method was abandoned because it did not seem to be possible, even with the aid of the dissecting microscope, to trace the accessory duct to its opening in the accessory papilla with any degree of certainty in a significant number of instances. An attempt was therefore made to demonstrate the ducts by injecting the system with vinyl plastic, after which the gland substance was macerated away with concentrated hydrochloric acid. This method was found to be unsatisfactory because of the marked distortion of the vinyl plastic which resulted when the gland was macerated.

Injection of the duct system with a suspension of litharge followed by its demonstration by means of a roentgenogram was also attempted. This technique was successful but the demonstration seemed indirect and, unless stereographic techniques were employed, two dimensional.

The thought occurred to me that a more effective way of demonstrating the ducts would be first

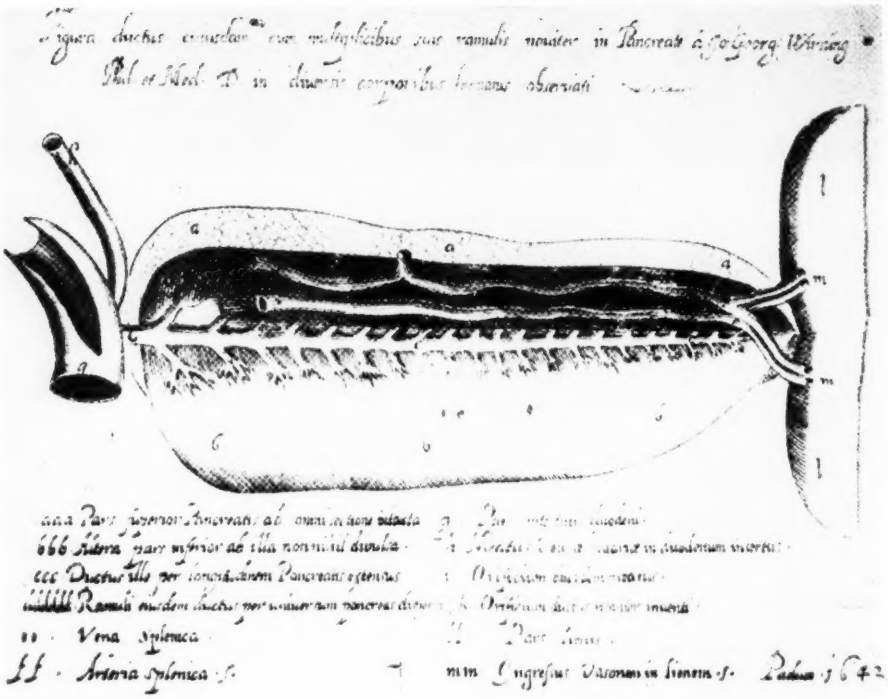


Fig. 1.—Reproduction of Wirsung's original illustration of the pancreatic duct system. Note that it has only a feeble resemblance to the true arrangement of the exocrine ducts of the gland in the human. (By permission of Surgery Publishing Company of Chicago.[18])

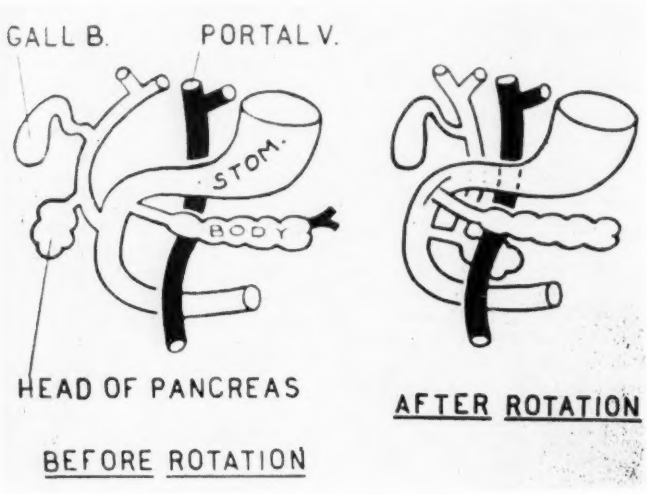


Fig. 2. — Illustration from Grant's "Method of Anatomy" showing the manner in which the pancreatic anlagen come in contact. (By permission of Williams & Wilkins Company, Method of Anatomy, Ed. 6.)

Fig. 3.—The commonest arrangement of the pancreatic ducts—found in 60% of specimens. The main pancreatic duct empties at the papilla of Vater, and the accessory pancreatic duct empties into the duodenum through an accessory papilla.

to inject them and then to clear the pancreas, permitting the ducts to stand out in the "ghost" of the cleared gland. The pancreatic specimens were first thoroughly fixed and partially dissected. They were then macerated in 5% potassium hydroxide solution until fat was saponified and the gland had achieved a soft consistency. At this point the dissection of the gland was resumed; excess fat and peritoneum were removed, and the specimen was partially dehydrated and acidified with 50% alcohol and hydrochloric acid. After thorough impregnation with the acid-alcohol mixture, the main pancreatic duct was discovered by transecting the gland near the junction of the body with the tail. The duct was cannulated and injected, usually with a latex solution but occasionally with vinyl acetate, after which the specimen was replaced in acid-alcohol and, finally, dissected again, removing all excess tissue. It was then advanced through increasing percentages of alcohol to absolute. When dehydration was complete, the specimen was transferred to methyl salicylate, where, after impregnation with the oil, the duct system was found to be clearly visible. Selected specimens were mounted in museum jars and photographed to produce a permanent record (Fig 3). In certain selected specimens the arterial supply was also injected to demonstrate the arrangement of the arteries that supply the pancreas.

RESULTS

In the 15 glands subjected to gross dissection after fixation, the main excretory duct was found to empty into the duodenum at the papilla of Vater in 12 instances (80%). In the remaining three instances, it emptied into the duodenum through the accessory papilla (20%). In the 12 instances in which the main duct emptied into the ampulla of Vater, the accessory duct could be demonstrated as patent in 3, or 25%. These figures, however, were not believed to be reliable because of the great difficulty in following the accessory duct to its ultimate end.

In 33 cleared and injected specimens, the main pancreatic duct was found to empty through the ampulla of Vater in 30 (90%) (Figs. 3 and 4) and through the accessory papilla in 3 (10%) (Fig. 4). In the 30 instances where the ampulla of Vater was the main excretory outlet of the gland, the accessory pancreatic duct could be demonstrated as opening through an accessory

papilla in 20 instances (67%). Thus, it was found that a patent accessory papilla exists in roughly 70% of cases and that it is capable of transmitting pancreatic juice in amounts varying from a little to most of the output of the gland.

In a selected number of glands the arterial supply was also injected prior to clearing. This is a difficult procedure to do completely in an excised and partially dissected gland. The conclusions reached, therefore, are the final, composite opinion developed from the study of several glands.

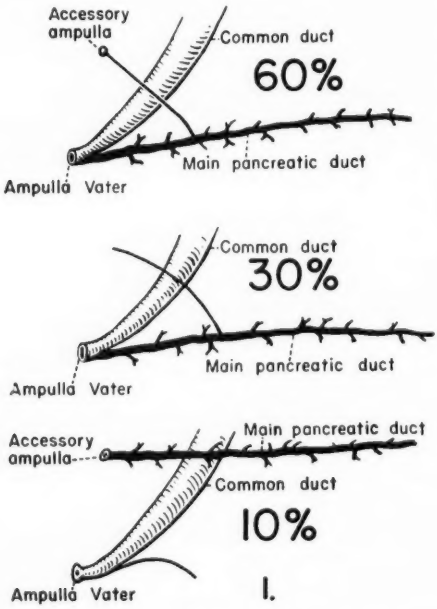


Fig. 4.—A schematic representation of the three variants of the arrangement of the pancreatic duct system. Note that these variations are predictable with an understanding of the embryologic development of the gland. Although the proximal end of the duct of the dorsal anlage atropies in 30% of persons, in the greater number of instances it remains open as a functional aditus for pancreatic secretion.

Finally, while dissecting a cleared specimen, it became apparent that the two embryologic components of the pancreas could be separated from each other by careful dissection. It was also found to be possible to achieve this separation in the formalin-fixed specimen with very little difficulty.

COMMENT

An attempt to understand the anatomy of the pancreatic ducts and their common variations without consideration of the embryologic development of the gland can only result in confusion. However, in the light of pancreatic ontogeny, the variations in the arrangement of the duct system become evident and eminently logical. The arterial supply also is better understood when the embryology of the gland is considered.

The pancreas arises as two outpouchings in the primitive foregut (Fig. 2). One of these buds extends into the dorsal mesentery and the other into the ventral mesentery, either in close proximity to or off of the hepatic bud (choledochus). The dorsal anlage is the larger of the two and is situated at a variable distance orad to the combined hepatic-ventral pancreas anlage. With the rotation of the bowel the larger dorsal anlage comes in close apposition with the ventral anlage; meanwhile, the greater curvature of the duodenum overgrows the lesser so as to place the two duct openings on the lesser curvature of the duodenum, although not in the same linear plane.*

After the two anlagen come in apposition, the duct systems unite at the edge of the ventral component. That portion of the duct of the dorsal anlage which lies between the point of fusion and the duodenum now undergoes a developmental arrest. This may be complete enough to produce partial (60%) (Fig. 3) or total (30%) (Fig. 4) atresia of the proximal end of the duct of the dorsal anlage. Occasionally there is no fusion between the duct systems (10%), and in this event each anlage has its own excretory orifice. Under such circumstances the duct of the dorsal anlage, since it drains most of the pancreatic tissue, can be said to be the main pancreatic duct. In this case, then, the main pancreatic duct can be said to empty at the accessory papilla, while the smaller duct of the ventral component can be called an accessory pancreatic duct emptying at the papilla of Vater. A significant finding

* Lotta, J. S., personal communication.

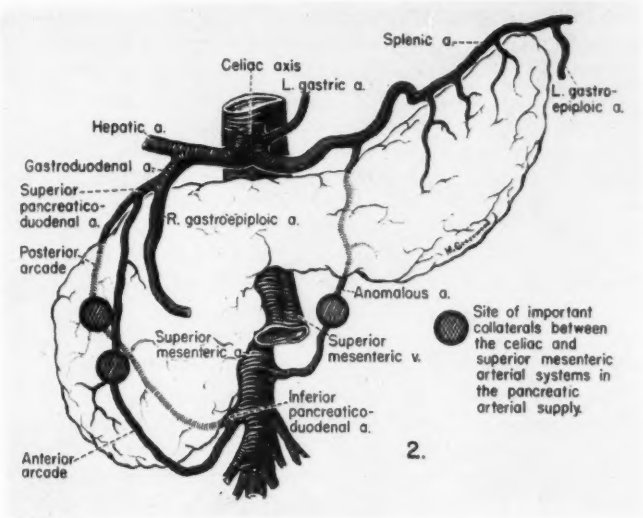


Fig. 5. — A diagram illustrating the important sources of pancreatic arterial supply from the celiac and superior mesenteric artery systems. The important collaterals between these systems in this area are indicated.

is that the accessory pancreatic papilla carries more or less pancreatic secretion in about 70% of persons while in 10% it transmits most of the exocrine secretion of the gland.

Interesting as these findings are, it was a distinct surprise to discover that the primitive division of the pancreas into two lobes persists into the adult. By careful dissection, it is indeed possible to demonstrate that the two embryologic components of the pancreas remain in the adult as two separable entities united only by a common duct system in the region of the neck of the gland. The remaining areas of the two components are readily separable by careful dissection without transecting any of the ducts. By such a dissection it is possible to demonstrate that the adult gland consists largely of dorsal component. The ventral component contributes little to the adult gland except its duct and the uncinate process, when it exists. In the 10% of instances when the two duct systems are separate the two embryologic components of the adult gland can be completely separated by careful dissection.

The bilobular arrangement of the pancreas is of further significance when one studies the arterial supply of the gland. It is at once apparent that the dorsal component receives its blood supply from the celiac axis by way of the splenic and hepatogastroduodenal systems. The ventral component, on the other hand, receives its blood supply from the superior mesenteric artery by way of the inferior pancreaticoduodenal artery. There are three significant collaterals between these systems: the anterior and posterior pan-

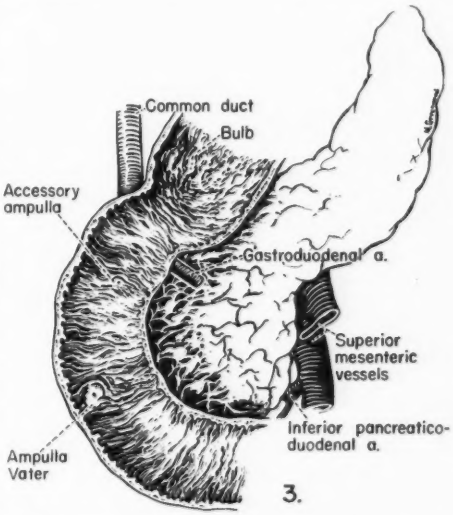


Fig. 6.—A diagram indicating important landmarks in gastrectomy. The common duct above and the gastroduodenal artery below mark the end of the duodenal bulb—beyond which it is not safe to dissect duodenum from pancreas.

creaticoduodenal arcades and a third, between the splenic and an anomalous (sometimes called inferior pancreatic) artery (Fig. 5).

In the face of the evidence of more or less independent duct systems, independent acinar arrangement, and separate arterial supply, it seems not unreasonable to consider the adult pancreas to be a bilobed organ.

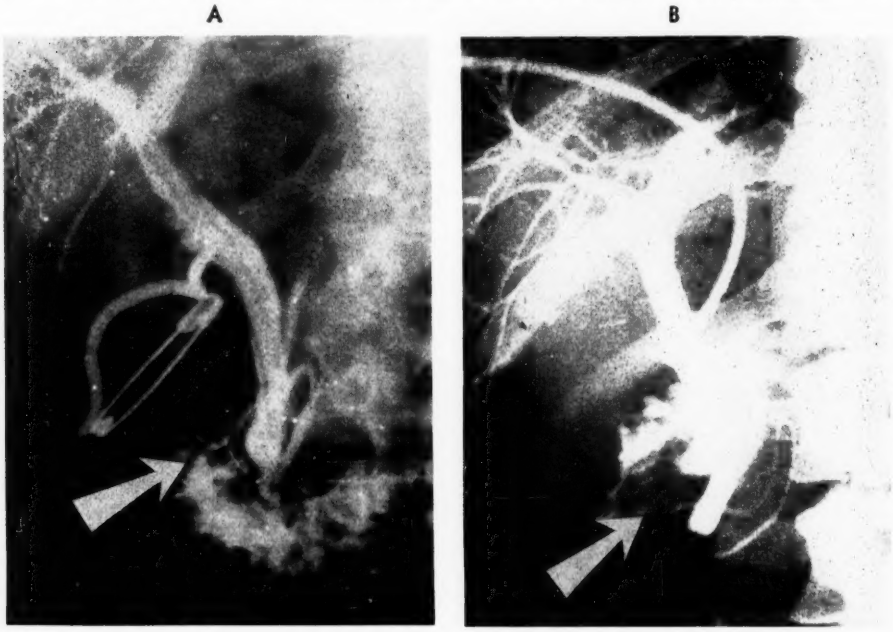
CLINICAL SIGNIFICANCE

This study was originally undertaken to determine the cause of postgastrectomy complications, particularly the periduodenal stump abscesses (called "blow-outs") and postoperative peritonitis. It was suspected that the accessory pancreatic duct presented more of a hazard than is generally appreciated.

As a result of this study it became apparent that the accessory pancreatic duct is a functional part of the pancreatic duct system—emptying into the duodenum at the accessory papilla in fully 60% of persons. In fact, in an additional 10% the accessory papilla is the exit for most of the pancreatic excretion. These facts are of profound significance in operations about the duodenum, since the accessory duct is usually so small and friable that it is impossible to demonstrate it by dissection of the gross specimen. Since an attempt to demonstrate the accessory pancreatic duct at the operating table could not be achieved with any reliable degree of success, it was believed more practical to identify landmarks to assist in avoiding the dangerous area rather than to recommend a search for the duct itself.

It was apparent from the dissections that the appearance of the intact gland could not be used as a guide to the arrangement of the duct system. It was further discovered that the accessory papilla could be demonstrated in only relatively few cases. It was necessary, therefore, to establish auxiliary landmarks. It was found that the bulb of the duodenum was regularly separable from the pancreas and could be dissected away with-

Fig. 7.—Two postoperative cholangiograms showing a patent accessory pancreatic duct (arrow). These cholangiograms prove the circulation of common duct content through the head of the pancreas, emitting into the duodenum through both of the pancreatic ducts. Neither of these persons had pancreatitis.



out endangering important structures. The distal end of the duodenal bulb, however, marked the area where duodenum and pancreas become inseparably bound together. This area of pancreatic-duodenal symphysis extends from the distal end of the bulb to the ampulla of Vater. After the ampulla is passed, the duodenum is free once again and can be dissected from the pancreas quite safely. For practical purposes the distal end of the duodenal bulb can be positively identified at the operating table as that point in the duodenum where the gastroduodenal artery passes below and the common duct passes behind (Fig. 6). It is not safe to dissect duodenum from pancreas beyond this point to the ampulla of Vater.

The intrapancreatic arrangement of the duct system must, furthermore, be considered in any discussion of the Opie "common channel" theory of pancreatitis. It appears that if this theory is true pancreatitis would be unlikely to develop in that 10% of persons who have the primitive duct arrangement with the main pancreatic duct emptying at the accessory papilla and only a rudimentary duct emptying into the ampulla of Vater. In those persons (30%) in whom the duodenal end of the accessory duct has atrophied, it remains to be explained how bile could overcome the greater secretory pressure of the pancreas to enter its duct system. It would explain, however, great increases in intraductal pressures associated with outlet obstruction.

Finally, in 60%, where a patent accessory papilla exists, a more or less efficient decompressing mechanism for the pancreatic duct system is present (Fig. 7). Such a decompressing mechanism would prevent excessive intraductal pressures following obstruction at the papilla of Vater. In those instances where a common channel exists in the ampulla of Vater, a decompressing mechanism through the accessory papilla would permit circulation of bile through the head of the pancreas.

SUMMARY AND CONCLUSIONS

1. The duct system of the pancreas is most clearly described by using four points of reference: the papilla of Vater, the accessory papilla, the duct of the dorsal anlage and the duct of the ventral anlage.

2. The ampulla of Vater is the major exit port for pancreatic secretion in 90% of persons. However, in 70% the accessory papilla is also patent and may transmit various amounts of secretion up to most of the glands output.

3. The embryologic origin of the pancreas from dorsal and ventral anlagen is demonstrable by dissection to show the bilobular nature of the gland.

4. The arterial supply of the gland derives from branches of the celiac axis (to the dorsal component) and of the superior mesenteric artery (to the ventral component). There are three important areas of collateral between these systems in the anterior and posterior arcades and in the inferior pancreatic artery.

5. It is unsafe to dissect pancreas from duodenum in the area of duodenal and pancreatic symphysis. This area extends from the distal end of the duodenal bulb to the papilla of Vater.

The significance of the intrapancreatic duct arrangement in pancreatitis is discussed. The patent accessory duct is identified as a decompressing mechanism for the pancreatic duct system.

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Suture Control of Bleeding Duodenal Ulcer

A Safer Approach in the Treatment of the Critically Ill Patient

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In recent years there has been increasing acceptance by internists and surgeons alike of emergency surgical treatment for the patient with uncontrollable massive hemorrhage from peptic ulcer. Progressively, enthusiasm has centered chiefly around the performance of subtotal gastrectomy. It is the purpose of this paper to suggest that the less extensive procedure of directing attention to the bleeding point only is a more rational approach and should result in a lower mortality.

Most authors agree that nonoperative treatment—with adequate blood replacement, early and frequent bland feedings, antacid therapy, and sedation—will effectively control the acute episode in the majority of patients with hematemesis or melena and that surgery should be reserved for those patients whose bleeding is uncontrollable, i. e., those in whom shock persists or recurs despite administration of 3 liters of blood or more a day to maintain the systolic pressure above 100 mm. and the hemoglobin above 8 gm. With this position, we are in general agreement.

However, this group of "uncontrollable" patients constitutes the greatest operative hazard, and, when surgical measures are taken in such a patient, we believe they should be those providing the least possible drain on the patient. Most authors recommend emergency subtotal gastrectomy. It is our feeling that duodenotomy or gastrotomy, with ready transection of the pylorus, generous exposure of the ulcer, direct suture control of the bleeding point—and no further surgery—constitutes the safest possible treatment for these gravely ill persons.

Subtotal gastrectomy carries today a very low mortality rate in the well-prepared and well-managed patient. There is, nonetheless, a definite mortality rate even in good-risk patients, as is seen (Table 1) in a random sampling of recently published mortality rates.* When these authors break down their figures by age groups, there is an appreciably greater mortality in patients more than 50 years of age (Table 2),† even in elective procedures with well-prepared patients. Most of the patients with uncontrollable hemorrhage are in this group more than 50 years of age.

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* References 2, 9, 12, 13, 15, 17, 18, 21, and 24.

† References 13, 18, and 21.

TABLE 1.—*Mortality of Subtotal Gastric Resection in Peptic Ulcers (All Types)*

Authors	Date of Series	No. of Cases	% Mortality
Baltz and others	1946-1951	128	1.6
Walters and others	1950	453	1.6
Gray and others	1952	408	1.5
Johnson and Orr	1948-1953	837	1.4
Kurzweg	1940-1950	320	6.3
Moore and others	1942-1946	175	2.9
McDonald and others	1948-1952	275	0.4
Stewart and others	1947-1951	120	4.0
Noring and Sjølin	1934-1951	859	5.1

Table shows an appreciable average mortality even in elective gastrectomy, i. e., 2.8% (102 deaths in 3,575 cases).

TABLE 2.—*Comparative Mortality of Subtotal Gastric Resection for Peptic Ulcers in Different Age Groups*

Authors	No. of Cases	% in Younger Groups	% in Older Groups
Kurzweg	320	1.3	7.9 (over 40 yr.)
Noring and Sjølin	859	2.9	8.0 (over 50 yr.)
Stewart and others	120	0.0	13.1 (over 60 yr.)

Table indicates that in elective gastrectomy there is a markedly higher mortality in the older age groups.

The patients with uncontrollable hemorrhage, though supported by multiple transfusions preoperatively, are by no means as good risks as elective patients. The former have been acutely depleted of blood and frequently have been sick for days or weeks prior to hemorrhage, with subnormal nutrition, loss of weight and strength, and disturbance of physiochemical balance. We feel that even expert and rapid subtotal gastrectomy in these patients adds the unjustifiable risks of prolonged anesthesia and major resection, without offering a better chance of control of bleeding than does simple bleeding point suture. Indeed, we feel it may offer less chance of bleeding control if the ulcer cannot be excised with the specimen and if blind gastrectomy is performed. The listed causes of death following this procedure show that recurrent bleeding from the ulcer is one of the most frequently mentioned conditions.

The fact that subtotal gastrectomy may be the desirable definitive treatment for the patient's ulcer, in our opinion, should not be considered at all in the emergency care of these patients. In 1946, Heuer wrote,[10] "The primary object of surgery is to control hemorrhage and save life; the treatment of the ulcer from an immediate viewpoint is secondary, as it is in acute perforation."

We suggest that the reported mortality figures for emergency surgery confirm the predicted greater hazard in these patients. It is extremely difficult to collect data on comparable cases, but some indication may be seen in Table 3.‡ These results indicate a consistent and appreciably higher mortality in emergency surgery (chiefly subtotal gastrectomy) than is found in elective gastrectomy. Indeed, it may be difficult to prove that the results are better than those reported with nonoperative treatment (Table 4).§ Admittedly, the criteria vary in these reports, but so do they in reports of operative treatment. Of particular interest in this regard is the comparison of figures for both operative and nonoperative treatment reported in four series of cases (Table 5) ||; if these authors used similar criteria in discussing the patients from these two categories, it is remarkable what parallelism exists between mortality figures for these two modes of treatment. It may be argued that in some of these instances the nonoperative mortality is improved because more seriously ill patients were subjected to surgery; if this is the case, the authors failed to mention this

‡ References 3, 4, 11, 19, 20, 22, and 23.

§ References 1, 5, 6, 7, 14, and 16.

|| References 3, 6, 20, and 23.

TABLE 3.—*Mortality of Emergency Surgery (Chiefly Gastrectomy) for Massive Hemorrhage*

Authors	Year Reported	No. of Cases	% Mortality	Criteria
Stewart and others	1952	110	11.1	Bleeding in previous week; red cell mass <60%
Bock and others	1954	25	8.0	Massive in ⅔ of cases
Thompson	1954	85	8.3	Continued or recurrent
Saltzstein and others	1953	68	5.9	Gross bleeding, all types
	....	14	28.6	Groups III & IV (Dunphy and Hoerr)
Brown and others	1950	36	11.1	Poor response after transfusion
Hoerr	1953	18	5.6	Massive
Rosenak and others	1952	20	25.0	Massive in ¾ of cases
Finsterer	1950	174	3.4	Syncope in most of cases

Table shows, in comparison with Table 1, the appreciably increased mortality associated with gastrectomy in the bleeding patient.

TABLE 4.—*Mortality of Nonoperative Treatment of Gross Bleeding of Peptic Ulcer*

Authors	Year Reported	No. of Cases	% Mortality	Criteria
Costello	1953	104	6.7	Shock; count <3 mill.
Andresen	1939	120	5.0	Average count 2.8 mill.
Meulengracht	1947	1,031	2.5	Hematemesis or melena
Crohn and Janowitz	1951	16,172	10.7	Massive
	....	...	6.9	Moderately severe
Crohn	1953	2,875	10.3	Massive; count 3 mill. or less
Lewison	1949	102	11.7	Massive

The mortality in medically treated patients compares favorably with that in patients who have emergency subtotal gastrectomy.

factor. Furthermore, it is undoubtedly true that in some instances patients who were moribund on admission or who were denied surgery because of an elevated NPN or other serious surgical contraindication are included in the nonoperative group and would tend to raise the mortality percentage in this group. In short, from these experiences it would seem that there is strong indication that emergency subtotal gastrectomy may not improve the mortality outlook for these patients.

We have too few patients treated by simple suture alone to draw any statistical conclusions. Nor have we found in the literature discussion of this method applied to any significant group of cases. The remarks that are made are confined to statements such as "mere ligation of bleeding vessels at base of ulcer . . . is unsatisfactory" [7] or "is completely inadequate," [23] without further elaboration or proof. On the other hand, it is interesting that some authors (Thompson,[23] Hoerr,[11] Dunphy and Gray [8]) are enthusiastic about precisely this procedure as a first step but then go on to perform further procedures.

Briefly, our procedure consists of a generous incision vertically through the midline or the left rectus in the upper abdomen, then extending across and down to the right of the umbilicus (Fig. 1). This affords excellent exposure for gastropyloroduodenotomy or for gastrectomy, should it be required in case no ulcer is found.

The ulcer is palpated, and a longitudinal incision (opening in one incision the antrum, pylorus, and duodenum, if necessary) is planned to afford wide exposure of the ulcer area. We do not hesitate to divide the pylorus and feel that wide exposure is one of the key factors in the success of this procedure. Hemostatic sutures (Fig. 2) are first placed on each side of the proposed incision, and the bowel wall is incised to expose the ulcer (Fig. 3). Multiple figure-of-eight sutures of cotton are placed in the ulcer bed to control bleeding adequately. If the patient's blood pressure is depressed at this point, pressure should be restored before the bowel is closed, to be sure that bleeding is completely controlled when pressure is normal.

Closure (Fig. 4) is made in Heineke-Mikulicz manner at the duodenal end of the incision, with simple reapproximation of layers of the gastric portion.

TABLE 5.—*Coincident Reports on Operative and Nonoperative Mortality in Treatment of Massive Hemorrhage*

Authors	Year Reported	Operative		Nonoperative		Criteria
		Cases	%	Cases	%	
Crohn	1953	805	10	2,875	10.3	Massive
Saltzstein and others	1953	14	28.6	20	35.0	Groups III & IV (Dunphy and Hoerr)
Bock and others	1954	25	8	302	5.3	Massive in ⅔ of cases
Thompson	1954	85	8.3	49	8.1	Massive

In each of the above series, operative and nonoperative mortalities are strikingly similar.

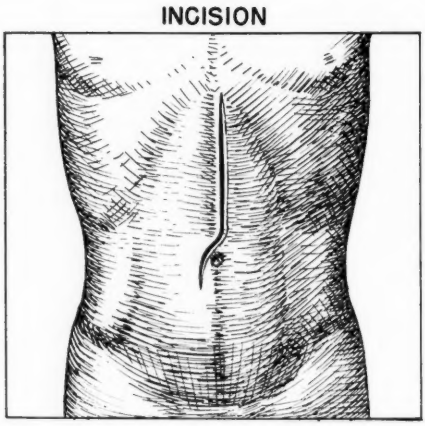

Fig. 1.—Upper left rectus incision is continued across the linea alba to become a right rectus incision, facilitating high gastric and adequate duodenal exposure.

We wish to relate briefly our experience with seven patients treated by simple suture. In six of them the blood pressure immediately returned to and stayed normal, and no further bleeding occurred. There was one fatality, Case 3. The six surviving patients have resumed normal activities, four having had definitive surgery performed at a later date. The remaining two have gone 9 months and 14 months, respectively, without further bleeding.

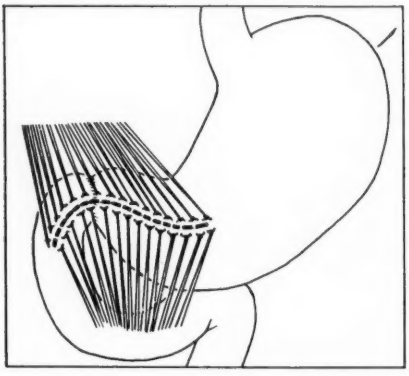

Fig. 2.—Before incising stomach, pylorus, and duodenum, a double row of sutures is placed for hemostasis and traction for exposure.

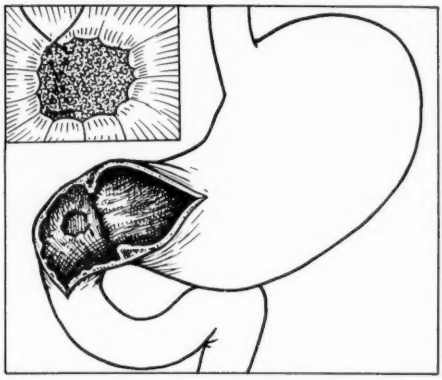

Fig. 3.—Incision is long enough to allow easy access to and suture of posterior wall ulcer. Inset shows method of single or multiple figure-of-eight suture.

REPORT OF CASES

Case 1.—A 60-year-old man, with a 10-year ulcer history, had been vomiting small amounts of blood for two weeks, with tarry stools. He had lost 20 lb. in three weeks. On admission, he was pale, with blood pressure of 90/60. He had 10 transfusions over the course of one week, but bleeding continued. On the seventh hospital day, pyloroduodenotomy was done, with finding of brisk bleeding from the base of a duodenal ulcer. Four figure-of-eight sutures controlled the bleeding. Recovery was uneventful. He had no more bleeding and in four

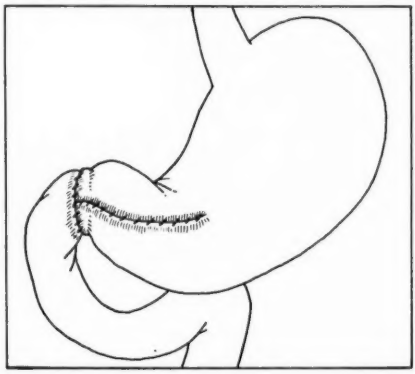

Fig. 4.—Combined transverse and longitudinal closure with running suture assures patency of pylorus and duodenum, eliminating need for gastroenterostomy.

months gained 20 lb. He returned at that time for definitive subtotal gastrectomy.

CASE 2.—A 48-year-old man had a 16-year ulcer history. The day before admission he had melena, followed by weakness and then collapse. During his first two days in the hospital he required 8 units of blood to combat shock. He underwent an exploratory operation on the third day, and a Meckel's diverticulum was excised, but no ulceration or bleeding point was found in it. The duodenal ulcer was also exposed. No bleeding vessel was seen, but the ulcer was closed with three figure-of-eight sutures. There was no bleeding postoperatively, and normal blood pressure was restored. No further bleeding occurred, and the patient returned in seven weeks for definitive surgery.

CASE 3.—In a 67-year-old man duodenal ulcer with 90% obstruction was demonstrated eight months previously and was treated medically. For 10 days before admission the patient had had constant nausea and vomiting. Shortly before admission he had massive hematemesis and went into shock; blood pressure on admission was 40 systolic. During his first four days in the hospital his blood pressure was almost constantly at shock levels, despite administration of 14 units of blood. Two days after admission his NPN was 125 mg. per 100 cc. He continued to vomit blood.

We were asked to see him on his fifth hospital day, at which time his NPN was 120 mg. per 100 cc. It was felt that surgery offered him his only chance, and ligation of a bleeding vessel at the base of a duodenal ulcer was done. He had no more hematemesis and no evidence of bleeding for two days, when the systolic pressure again fell and he had melena. NPN remained elevated; he had hallucinations, was incontinent, and died on his sixth postoperative day. Permission for autopsy was not obtained.

This patient falls in the category of patients who would be denied surgery in some hospitals. On the other hand, death certainly seemed inevitable without surgery. He is the only patient in our group who showed evidence of further bleeding following surgery. Perhaps surgical consultation at the onset of his bleeding would have resulted in a happier conclusion.

CASE 4.—A 58-year-old man had a long history of ulcer. On our arrival on the floor to see the patient, the nurse said he had just died. He was indeed in deep shock and unconscious. Elevation of his legs, wrapping of extremities with Ace bandages, and immediate infusion of dextran and blood restored consciousness and blood pressure. Immediate active hematemesis occurred. During the day there was massive melena and the pressure again fell. With the operating team ready, the patient was given transfusions (2000 cc.) in both arms and one leg and by the time of operation had received a total of 9 pt. (about 4500 cc.) of blood. Pyloroduodenotomy showed a spurting vessel in a 1½ in. ulcer crater. Three figure-of-eight cotton sutures controlled the bleeding. By the second postoperative day the Levin tube drainage was only brown, and the patient had no further evidence of bleeding. On the 10th day he had a wound disruption which was repaired.

He returned four months later for definitive surgery and eight months later was well and at work.

CASE 5.—A 46-year-old man had had ulcer symptoms for two years and a perforation four months previously. He was found at home on the bathroom floor, in shock, after vomiting blood. During the next 60 hours he had 10 units of blood, with three more hemorrhages, and at one time his blood pressure was unobtainable. On the third day after admission he was prepared with 4 pt. (about 2000 cc.) of blood, and exploration was done. A deep tunneling duodenal ulcer was found. By pressure externally, the base of the ulcer was brought into view; a spurting vessel was seen and tied off with one figure-of-eight suture. There was immediate stoppage of bleeding. Within 24 hours his Wangensteen drainage was clear and watery. The patient had not returned for definitive surgery nine months later.

CASE 6.—A 68-year-old woman had had bleeding from an ulcer three years previously. On this admission she was given a daily transfusion, which seemed to support her adequately. However, she had emphysema and dorsal kyphosis, and she developed bronchopneumonia by the seventh hospital day. Her anemia became severer and she was failing; a medical consultant suggested that only surgery could save her life. She had by this time received 10 transfusions.

Operation demonstrated no ulcer crater, but there was stippling of the serosa in the first part of the duodenum and bright red blood was issuing from the mucosa just beyond the pylorus. This area was sutured.

No more bleeding occurred. Late on the first postoperative day her gastric drainage was greenish-brown. Recovery was uneventful and rapid, without further hemorrhage.

She has not had definitive treatment. The medical consultant does not advise further surgery because of her kyphoscoliosis and emphysema.

CASE 7.—A 49-year-old man was admitted with hematemesis of two days' duration. He did well on conservative treatment for two days, when he had a tarry stool, went into collapse, and vomited a basinful of blood; blood pressure was unobtainable. Pressure was restored with transfusions—he received five in the first two hospital days—and exploratory operation was performed. A 2 cm. gastric ulcer was exposed; it was not bleeding actively.

Several over-and-over sutures of cotton were placed in the base of the ulcer, and a free omental graft was tied down into the ulcer with the ends of the cotton sutures. The patient recovered uneventfully, and on the first postoperative day the Wangensteen drainage was green.

He returned four months later for definitive surgery, having had no bleeding in the interim.

COMMENT

These cases indicate that adequate direct suture of the bleeding ulcer is a satisfactory method of stopping blood loss, which is the sole requirement of emergency surgery in these poorest-risk patients. Gastrojejunostomy is not needed, for pyloric obstruction is avoided by transverse closure of the pyloric portion of the longitudinal visceral incision. We feel that the simplicity of this method renders it much safer than subtotal gastrectomy with or without excision of the ulcer. We believe it deserves further trial.

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A Simplified One-Stage Operation for the Correction of Lymphedema of the Leg

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During the past 50 years the emphasis in the treatment of chronic lymphedema of the legs has slowly shifted from operations designed to establish new lymphatic channels to more and more radical excisions of the diseased subcutaneous tissue. It is highly debatable whether such operations as lymphangioplasty by means of buried silk (Handley, 1908), the excision of long strips of deep fascia (Kondoléon, 1912), or the transfer of skin flaps to bridge the postulated lymphatic barrier in the groin (Gillies and Fraser, 1935; Mowlem, 1948) do, in fact, provide fresh functioning lymphatic pathways, and their results have been disappointing. Much of the temporary improvement which ensued could be explained by the associated rest in bed. Furthermore, when lymphedema persists for any length of time, there is a gradual deposition of new fibrous tissue in the edematous subcutaneous compartment; in other words, there occurs a progressive "organization" of the edema fluid. A return to normal size, therefore, becomes impossible with improvement in drainage alone, even if this could be achieved.

The success of the Kondoléon operation, which was popular for many years, probably derived from the fact that those who used it were conscious of the need to excise as much of the edematous subcutaneous tissue as possible during the dissection (Sistrunk, 1918 and 1927; Pratt and Wright, 1941). It was noted, however (Ghormley and Overton, 1935), that unless firm restraining bandages were constantly used, there was a recurrence of the edema, arising presumably from progressive enlargement of the remaining subcutaneous tissue.

Homans (1936) was the first to design an operation to remove all the subcutaneous tissue of the lower leg. This was a multiple-staged excision in which access was obtained by raising a series of longitudinal skin flaps which were replaced after the subcutaneous tissue had been excised. Since then, several other techniques have been described in which free-skin grafts have been used to repair the defect after excision (Macey, 1940 and 1948; Poth, Barnes, and Ross, 1947; Mowlem, 1948; Blocker, 1949; Farina, 1951; Campbell, Glas, and Musselman, 1951, and Platt, 1951 and 1953).

The use of free-skin grafts instead of the pedicled flaps of Homans makes possible the one-stage operative correction of the whole of the lower leg and the dorsum of the foot. To accomplish this expeditiously with a minimum of shock and blood loss requires a carefully planned surgical technique. The operation to be described has been evolved over a number of years (Gibson and Tough, 1954) and in its present form enables two surgeons working together to complete the operation on one leg in about one and one-quarter hours. Blood loss is negligible, and postoperative shock has not been a feature.

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Plastic Surgery Unit, Royal Infirmary.
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Fig. 1.—To obtain access to the full circumference of the lower leg and to the dorsum of the foot, the affected leg is suspended by means of an ice-tong calliper inserted in the calcaneus and a rope passing through a pulley in the theater ceiling; the other leg hangs downward from the knee. A pneumatic tourniquet is applied to the thigh. (Reproduced with permission from Gibson and Tough, *British Journal of Plastic Surgery*, E. & S. Livingstone, Ltd., Edinburgh, 1954.

INDICATIONS FOR OPERATION

The decision as to what degree of lymphedema justifies operation must remain an individual one, and it is in the milder cases that doubts arise. If a return to normal or near-normal size follows complete rest in bed with elevation of the leg, the disease process may be held in check by firm bandaging. The size of the leg should not be the only criterion; life may be intolerable to a young woman with a degree of swelling which would be of little importance in a man. Again, a unilateral swelling is a greater cosmetic handicap than a bilateral swelling of similar degree. One firm indication for operation is a history of recurrent episodes of cellulitis in the leg. In our experience the grafted area of the leg has remained completely free from such attacks.

PREOPERATIVE TREATMENT

The patient is confined to bed with the foot of the bed elevated. Daily measurements of the circumference of the leg at various fixed points will show a fairly rapid initial decrease in size which gradually tails off until no further improvement occurs. The swelling of the leg becomes firmer and finally nonpitting. At this point the operation is carried out. This preliminary recumbency,

Fig. 2.—A plaster of Paris shoe provides an alternative method of suspension when bone traction is contraindicated, as for example when the skin is ulcerated. The area on the dorsum of the foot must of course be dealt with at a secondary operation. (Reproduced with permission from Gibson and Tough, *British Journal of Plastic Surgery*, E. & S. Livingstone, Ltd., Edinburgh, 1954.

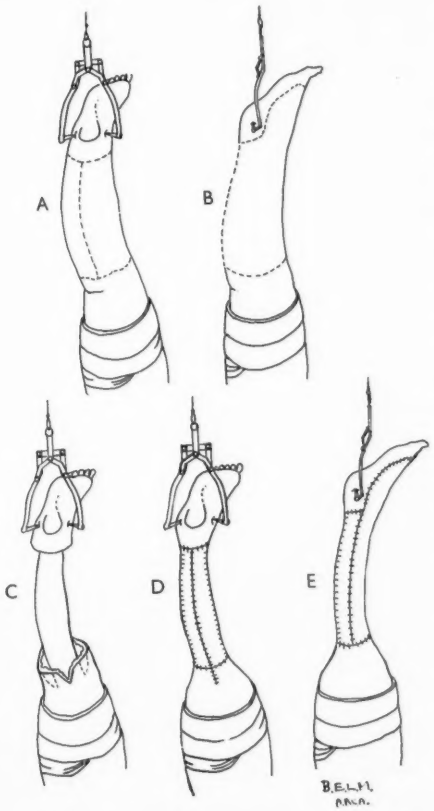

Fig. 3.—A diagrammatic representation of the incisions used and the skin replacement. *A* and *B* show the extent of the excision. *C* illustrates the "thinning" of the area below the knee by excision of a wedge-shaped mass of subcutaneous tissue. The areas over the malleoli are similarly treated. *D* and *E* show the free grafts sutured in position. (Reproduced with permission from Gibson and Tough, *British Journal of Plastic Surgery*, E. & S. Livingstone, Ltd., Edinburgh, 1954.

during which the excess edema fluid is absorbed, simplifies the subsequent operation.

OPERATIVE TECHNIQUE

A pneumatic tourniquet is first applied. The cloth cover of the usual thigh cuff is not long enough for a lymphedematous thigh, and we use a specially made cover about 7 ft. long, which can be wrapped several times around the leg. This must be bandaged firmly in place and fixed above and below with adhesive strapping to prevent it slipping down the thigh.

The affected leg is raised to a vertical position by means of a rope passing through a pulley in the theater roof and attached to an ice-tong caliper inserted in the calcaneus (Fig. 1). Should the leg be ulcerated or any other contraindication to bone traction be present, a plaster of Paris shoe (Fig. 2) may be substituted for the bone caliper, but this prevents access to the dorsum of the foot. When the other leg is allowed to hang downward from the knee, free access can be obtained to the whole circumference of the affected leg. The tourniquet is now inflated to a pressure of from 200 to 240 mm. of mercury; occasional reinflation is necessary, since the pressure of the tourniquet tends to displace any remaining edema of the thigh, with a resulting fall in the pressure.

Three incisions are used (Fig. 3). The first circumscribes the leg just below the lower border of the patella; the second passes around the dorsum of the foot and ankle, leaving intact an area covering each malleolus and the insertion of the tendo achillis, and the third incision runs midway posteriorly between the other two.

The midline posterior incision is deepened down to the deep fascia, and with one surgeon working on each side the whole mass of skin and subcutaneous tissue is removed from the leg. The dissection is made just superficial to the deep fascia, which should be left intact. Small herniations of muscle through fascial defects may spoil the cosmetic effect. It goes without saying that the paratenon covering the tendons in front of the ankle and the tendo achillis should be carefully preserved.

The mass of edematous tissue (Fig. 4) is removed to a side table, and the skin is prepared for reapplication to the leg as a free graft. The mass is first divided into three longitudinal strips, each of which is in turn laid flat on a board. The underside is packed with cotton-wool until an even surface is obtained (a tendency to curl at the edges can be corrected by a few longi-

tudinal cuts in the subcutaneous tissue). An assistant steadies one end with tissue forceps while the graft is cut from the surface by means of a Humby knife (Fig. 5). The skin is removed at or about full-thickness level, the knife passing through the dermal fat papillae, and the whole of the skin of each strip is removed in one piece. The three strips are then sutured together in their original sequence (Fig. 6).

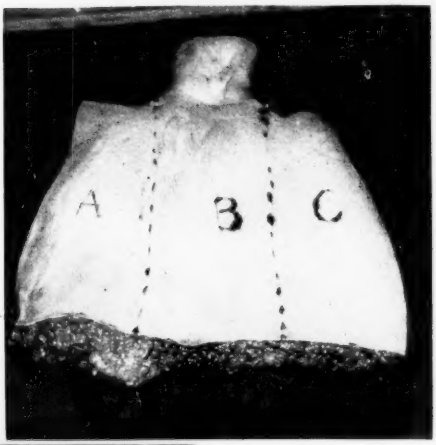

Fig. 4.—After excision the mass of edematous tissue is divided into three labelled strips. (Reproduced with permission from Gibson and Tough, *British Journal of Plastic Surgery*, E. & S. Livingstone, Ltd., Edinburgh, 1954.)

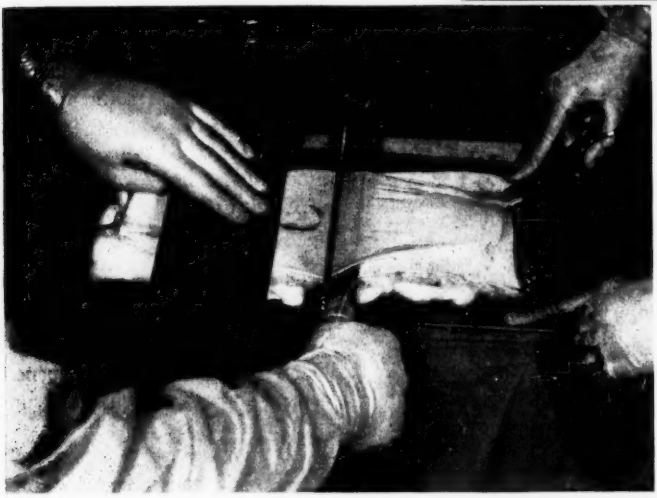

Fig. 5.—Each strip is placed on a wooden board, and an even surface is obtained by cotton-wool padding. The skin is removed with a Humby knife at practically full-thickness level. (Reproduced with permission from Gibson and Tough, *British Journal of Plastic Surgery*, E. & S. Livingstone, Ltd., Edinburgh, 1954.

While the skin graft is being prepared, the second surgeon completes the dissection by undermining the skin below the knee and removing a circumferential wedge of subcutaneous tissue. In the same way the flaps covering the malleoli on each side are turned back and as much of the excess tissue as possible excised. When all remaining tags of edematous tissue have been removed, the tourniquet is released and hemostasis secured.

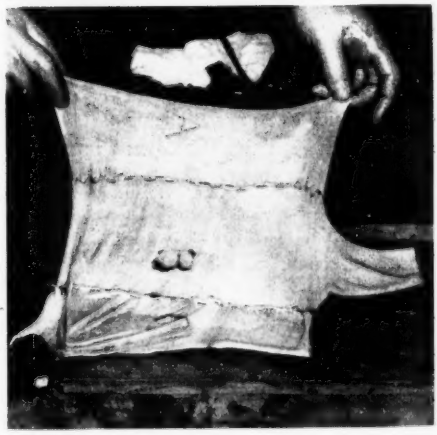

Fig. 6.—The three strips of skin are sutured together with a running mattress stitch in their original position before they are reapplied to the leg. (Reproduced with permission from Gibson and Tough, *British Journal of Plastic Surgery*, E. & S. Livingstone, Ltd., Edinburgh, 1954.)

Fig. 7.—Woman, aged 45. Idiopathic lymphedema of 28 years' duration.

Fig. 9.—Woman, aged 42. Idiopathic lymphedema of the right leg for 5 years.

Fig. 8.—The appearance of the leg 6 months after operation. The glossy appearance of the skin is common to all these patients.

Fig. 10.—The appearance of the leg 18 months after operation. Two small areas of recurrent edema on the outer aspect of the leg are probably due to incomplete excision.

The skin graft is fixed in position by suturing it to the wound margins above and below. There is a considerable excess of skin circumferentially, and this is excised posteriorly so that the final suture line lies in the midline. To obtain a neat closure below the knee, it is usually necessary to excise a small triangular piece of skin posteriorly as shown in Figure 3.

A firm pressure dressing is applied by use of several layers of acriflavine wool fixed

Fig. 11.—Woman, aged 37. Idiopathic lymphedema of the left leg for 10 years. (Reproduced with permission from Gibson and Tough, *British Journal of Plastic Surgery*, E. & S. Livingstone, Ltd., Edinburgh, 1954.)

with crepe bandages. Care must be taken not to have too much pressure over the front of the ankle, since this can lead to loss of the graft and superficial necrosis of tendons. Finally, when the leg has been lowered and the caliper removed, a plaster of Paris cast is applied from the toes to the upper thigh.

Postoperative Care.—The patient is nursed with the end of the bed raised, and the

Fig. 12.—Immediately postoperatively the leg is much thinner than normal. In this case the dorsum of the foot was corrected at a secondary operation.

Fig. 13.—Fourteen months after operation the calf has filled out and the leg contours are more normal. (Reproduced with permission from Gibson and Tough, *British Journal of Plastic Surgery*, E. & S. Livingstone, Ltd., Edinburgh, 1954.)

dressing is not disturbed until the 10th day. At this stage a mature circulation has not been established, and the grafts may appear mottled and discolored, even though a perfect take has occurred. The pressure dressing is reapplied at intervals until healing is complete; only then is the patient allowed up. When ambulant, the patient wears firm bandages from the toes to above the knee, and these are retained for about three months after operation, when they may safely be discarded.

RESULTS

Using the technique described, we have operated upon eight patients with idiopathic lymphedema, six of whom were females; in two cases both legs were affected, and a total of 10 operations have been performed. These patients have been recently reviewed (October to November, 1954) for the purpose of this report, the longest follow-up period being 2 years. At the same time we reviewed an earlier series of eight patients in whom the technique was similar but carried out in two stages, the dorsum of the foot being dealt with later (Gibson and Tough, 1954); the longest follow-up in this group was 4 years. The results described and illustrated below are particularly those of the latest group, treated by the one-stage operation. When applicable, however, we have drawn upon the experience gained from the longer follow-up period of the earlier cases.

Symptomatic Relief. — All the patients were grateful for the dramatic decrease in size of the leg and for the reduction in weight; those who had previously been subject to recurrent attacks of cellulitis have been free from further attacks in the lower leg, but one has had a minor attack in the thigh. This latter case is the only one we have seen who has had any recurrence of cellulitis following the operation.

Recurrence of the Edema.—There has been no generalized recurrence of the swelling in either series of cases, but localized recurrences have been seen in three situations: around the malleoli, on the dorsum of the foot, and in small areas on the leg itself. The only one of any moment has been that around the malleoli, and in four instances it has been necessary to carry out a secondary operation at this site. Theoretically, this might be avoided by adequate "thinning" of these regions at operation, but in practice it has not always been possible to achieve this. The recurrence of edema on the dorsum of the foot is very slight but is common to all cases and is associated with the difficulty of removing all the subcutaneous tissue of that region without damaging the underlying tendons and paratenon. It is kept in check by the shoes and is not progressive. Edema will recur in any tags of subcutaneous tissue overlooked, and meticulous care is required to see that all are removed. There is a natural fear of damage to the periosteum over the subcutaneous surface of the tibia while carrying out the excision, and it is there in particular that small pieces may be left behind.

Cosmetic Results (Figs. 7 to 15).—These have been much better than we have achieved by other techniques. While the leg is at first obviously smaller than normal because of the complete absence of subcutaneous tissue, it fills out and becomes more rounded when the patient is ambulant. Whether this is due to the disappearance of the muscle wasting which follows the enforced recumbency or to some edema of the muscles themselves is not certain. It does not, however, appear to be progressive. Any small areas of recurrent edema and any small muscle herniae may cause surface irregularities and detract from the appearance. On the whole, our best cosmetic results have occurred with the less severe types of case.

Sensation in the Leg and Foot.—The subcutaneous nerves on the lower leg are removed, as is also the saphenous nerve. The sole and the toes, however, are supplied by branches of the tibial nerve which passes behind the medial malleolus and remains intact. There is virtually no sensation in the lower leg apart from variable areas

Figs. 14 and 15.—Twenty-seven months after operation there has been little change and no recurrence of the edema.

just below the knee. This anesthesia appears to cause no disability; in fact, most of our patients were unaware of it until it was demonstrated to them. Patches of sensation may be present in the graft over the dorsum of the foot, but these are inconstant. Sensation is normal over the sole and toes.

Changes in the Skin.—In the early cases which were treated by the Homans procedure or by multiple excisions and grafting, the development of a warty hypertrophy of the skin was noted (Gibson and Tough, 1954). We have been glad to find that this has not been a feature of the cases under review. While a tendency to warty change was noted in one or two patients on the skin of the dorsum of the foot and around the ankle, this has not progressed and has caused no trouble.

This warty appearance of the skin occurs in the free grafts where they join edematous skin. It was particularly prone to develop, therefore, in cases of multiple excision or when an edematous strip was left covering the subcutaneous surface of the tibia. It is also our impression that it was severer when split-skin grafts were used to cover the resulting defect.

SUMMARY

A one-stage operation is described for lymphedema of the leg.

By this means correction of the whole of the lower leg and dorsum of the foot can be achieved expeditiously with a minimum of blood loss.

The results of 10 operations in eight patients are reviewed, the longest follow-up period being two years. A previous series of eight patients who had a similar operation, but in whom the dorsum of the foot was corrected secondarily, is also reviewed, the longest follow-up being 4 years.

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Urinary Diversion

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The problem of urinary diversion has assumed increasing importance during the past few years. With the development of adequate bowel preparation and the advent of chemotherapeutic agents for the control of upper urinary tract infection, the heretofore prohibitive operative mortality and morbidity following urinary diversion have been reduced to such an extent that the utilization of this procedure need no longer be looked upon as condemning the patient to a life of invalidism followed by early death.

A careful study of the literature of the past 20 years leads one to some interesting conclusions. Irrespective of the method used, one must conclude that the upper urinary tract is rarely completely normal after diversion and that longevity is unquestionably jeopardized to a varying degree. However, one must consider the fact that in conditions in which urinary diversion is employed longevity is already in jeopardy as far as the upper urinary tract is concerned.

The commoner conditions for which urinary diversion is employed are as follows: (1) extrophy of the urinary bladder and epispadias; (2) inoperable vesicovaginal fistula; (3) intractable interstitial cystitis; (4) advanced vesical tuberculosis when all other forms of treatment fail; (5) crushing injuries to the pelvis with extensive destruction of the male urethra; (6) advanced destructive disease of the urethra, "watering-pot perineum"; (7) extensive scarring of pelvic ureters due to prior surgery or radiation treatment; (8) cystectomy for carcinoma of the urinary bladder or urethra, and (9) pelvic evisceration for extensive carcinoma of pelvic organs (excluding carcinoma of the prostate and advanced bladder carcinoma).

In 1936, Hinman and Weyrauch [1] covered all methods of ureteral diversion of urine in an extremely adequate fashion. Since then, urological surgery has advanced in seven-league boots and a reappraisal of the various methods of diversion would seem to be in order. The following general types of diversion are discussed: (1) ureterocutaneous anastomosis, (2) the Boyce-Vest procedure for exstrophy of the bladder, (3) ureterosigmoidostomy with wet colostomy, (4) the establishment of a reservoir utilizing the cecum and terminal ileum, (5) transplantation of ureters into the isolated rectal ampulla, (6) ureterosigmoidostomy with rectal pouch and colostomy above, (7) ileal segment bladder substitution, and (8) ureterosigmoidostomy in the intact colon.

URETEROCUTANEOUS ANASTOMOSIS

A great deal has been written concerning ureterocutaneous anastomosis. Most of the articles dwell on the mechanics of producing a good stoma and on the management of the inevitable urinary leakage. It would appear that insufficient emphasis has been placed on the most obvious objection to ureterocutaneous anastomosis; namely, the high incidence of such complications as abscess along the course of the ureter, dilatation of the upper urinary tract, recurrent renal calculi, and recurrent urinary tract infection.

The most complete series with long-term follow-ups are those of Humphreys [2] and Abeshouse.[3] Humphreys analyzes a series of 50 cases, 32 of carcinoma of the bladder, 11 of tuberculous cystitis, and 7 of other diseases. After diversion, all the cases with carcinoma of the bladder had varying degrees

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of hydronephrosis bilaterally, with infected urine; there were six cases of renal calculi, and the five-year survival was only 9%. Among the tuberculosis cases, the operative mortality was 27%; of the survivors, 27% developed late abscesses around the anastomosis and all had same degree of hydronephrosis and infection. In Abeshouse's series of 30 cases—24 of carcinoma, 2 of neurogenic bladder, 2 of incontinence, 1 of tuberculosis, and 1 of stricture of the ureter—there were 5 postoperative deaths, all in the carcinoma group. Although these patients were admittedly in poor condition prior to surgery, it is surprising to find that Abeshouse lists uremia as the cause of death in 18 cases (more than 50%). Ureteral dilatation was present in 20 and urinary infection in 27 of the 30 cases. Of the so-called "living and well" group consisting of seven cases, only two had failed to develop renal complications of a serious nature. Burns, Kittredge, and Hyman,[4] in 1947, collected 41 cases from the literature and added a case of their own. Of these cases, 16, or 38%, were reported as well, with 26, or 62%, presenting major upper urinary tract complications. An analysis of all the recent literature reveals a total of 188 cases in which sufficient information is available to form an opinion. Of these, the results could be termed as good in 65, or 34.6%, and poor in 123, or 65.4%.

Because I do not favor this method of diversion, my own experience has consisted of only three cases. One of these patients had repeated abscesses about the stoma but has done satisfactorily for the past two years. The second patient has had a persistent upper tract infection of rather marked severity and presents a continuous problem of stricture of both stomata. The third, and probably the best, was a case of exstrophy who had had bilateral cutaneous ureterostomies secondary to a poorly functioning ureterosigmoidostomy 17 years before coming under my observation. He had enjoyed reasonably good health during the interval but was subject to an occasional bout of pyelonephritis.

From the above review, one can conclude only that ureterocutaneous anastomosis carries an even higher upper tract morbidity than does ureterosigmoidostomy. Superimposed on this progressive upper tract disease is the added mechanical difficulty of management of the urine. The only cases in which ureterocutaneous anastomosis would seem justified are those of intractable tuberculous cystitis with a single dilated ureter and those with such extensive scarring of the pelvic ureters as to make reimplantation into either the rectosigmoid or an isolated segment of ileum technically impossible. In those cases in which stenosis and hydroureter have developed after ureterosigmoidostomy, reimplantation into the isolated rectosigmoid with a colostomy above or into an isolated segment of ileum is preferable to ureterocutaneous anastomosis.

BOYCE-VEST PROCEDURE FOR EXSTROPHY OF THE BLADDER

Although the Boyce-Vest procedure embodies the principle of diversion of the urine into an isolated rectal pouch, it avoids any disturbance of the ureterovesical mechanism. Therefore, I believe it should be given special consideration. The principle involves bisecting the trigone and creating a stoma between the bladder and a previously prepared isolated rectal pouch which has been sterilized as much as possible prior to operation. Boyce and Vest[5] report two cases followed for a fairly long period, with sterile cultures from the rectal pouch and with normal upper urinary tracts on intravenous pyelography.

I have utilized the procedure in two cases; in one case the operation was performed a year and a half ago, and in the other, eight months ago. Neither child has shown any signs of sepsis, and the upper urinary tracts are normal on intravenous pyelography. These children are growing and developing in a perfectly normal fashion, and their electolytes have remained normal. The procedure does carry the disadvantage of a permanent colostomy. However, this is a small price to pay for a normal life ex-

pectancy. Although it will be many years before final evaluation can be made, all factors would seem to indicate that this method holds great promise.

URETEROSIGMOIDOSTOMY WITH WET COLOSTOMY

The "wet colostomy" principle has been used and reported on by Brunschwig and associates * in connection with pelvic evisceration for advanced carcinoma of the various pelvic organs. It consists of implantation of the ureters into the descending colon just proximal to the colostomy. The mechanical difficulties of management of wet colostomies are self-evident. In a series of 22 cases, there was a 23% operative mortality, with 3 of the deaths being definitely referable to urinary diversion. The authors' follow-ups do not cover any great period of time, the longest reported survival being two years. A study of their case histories shows that the condition of at least seven of the survivors was definitely unsatisfactory from a renal standpoint. Because there is no stasis of urine in the colon, hyperchloremic acidosis has not been a problem with this procedure. I have had no personal experience with this method, and I doubt whether it will ever receive wide adoption.

ESTABLISHMENT OF A RESERVOIR USING THE CECUM AND TERMINAL ILEUM

The utilization of an isolated cecal pouch with the appendix as a urethra was first described by Verhoogen † in 1908. Similar procedures were subsequently reported by Makkas [9] in 1910 and Lengemann [10] in 1912. Twelve early cases with this type of procedure were recorded. There were eight operative deaths, a mortality rate of 66%. In 1951, Merricks and associates [11] proposed a modification of this method whereby the cecum and distal ileum are isolated, the ileal segment being brought out to the anterior abdominal wall in an antiperistaltic fashion, thus producing continence. The cecum serves as a reservoir, and the patient empties the pouch by self-catheterization at regular intervals. Merricks and Gilchrist later reviewed 18 cases,[12] 16 of carcinoma of either the urinary bladder or other pelvic organs and 2 of benign lesions. There were five postoperative deaths, and an analysis of the postoperative pyelograms presented in six cases showed that seven renal units were good, while five displayed moderate upper tract dilatation, one requiring reoperation. The incidence of pyelonephritis was only 28.6%, and there was no notable hyperchloremic acidosis.

Harper, Berman, Hertzberg, Brendler, and Brendler [13] report seven cases with two operative deaths (28.3%), with good upper urinary tracts in the five survivors. The longest follow-up was for six months. Moore [14] records a single case with what he terms an excellent result at the end of eight months.

My personal experience with a cecal pouch has consisted of one case. I did not utilize the Merricks-Gilchrist procedure but formed a cecal pouch with a cecostomy and a retention catheter. The formation of mucus was so excessive as to create a very genuine problem, and eventually a large opening was made into the cecum and a Rutzen bag applied for collection of urine. Although Merricks and Gilchrist do not report any difficulty with mucus formation, this complication should be given serious consideration. In addition, it would seem that the continuous self-catheterization, with the accumulation of stagnant urine between each catheterization, would predispose to frequent bouts of urinary tract infection.

From an evaluation of the available literature, one must conclude that this method may have some merit. A long-term study will be required before its eventual value can be determined.

TRANSPLANTATION OF URETERS INTO THE ISOLATED AMPULLA OF THE RECTUM

According to Hinman and Weyrauch, transplantation of the ureters into the isolated

* Reference 6 and 7.

† Verhoogen,[8] cited by Hinman and Weyrauch.[1]

rectal ampulla was first described by Gersuny in 1898. In 1912, Heitz-Boyer and Hovelacque [15] gave a further report with excellent illustrations. Mikuli,‡ in 1930, described a similar method. Further modifications were reported by Lastaria [17] in 1915 and Melnikoff [18] in 1924. In 1953, Levitsky [19] presented four cases, with one operative death (25%). There was one survival of 20 years following total cystectomy and prostatovesiculectomy for adenocarcinoma of the prostate. In 1955, Lowesley and Johnson [20] described two additional cases treated by the same method, with excellent clinical results at the end of six months.

I have had no personal experience with this procedure. The obvious difficulty would seem to be in obtaining an adequate blood supply to that portion of the sigmoid which is brought down through the rectal sphincter. Furthermore, the close proximity of the two orifices with an unquestionably damaged sphincter mechanism presents a strong possibility for recurrent infection. This procedure will require an extended period of evaluation, and it is doubtful whether it will attain any wide acceptance.

URETEROSIGMOIDOSTOMY WITH RECTAL POUCH AND COLOSTOMY ABOVE

Diversion of the fecal stream above the rectosigmoid was first tested by Mauclaire [21] in 1895. He advised the establishment of a perineal anus through the left ischiorectal fossa. Remedi [22] was the first, in 1905, to use the procedure in human beings. Krönig [23] in 1907, Rovsing § in 1915, and Schmieden || in 1922 recommended this method. The last-named author reported eight cases, with a surgical mortality of 25%. In 1951,[27] we recommended this procedure as a possible means of combating hyperchloremic acidosis. In 1953, Kinman, Houston, and Melick [28] reported on eight cases, the longest survival being two and one-half years. They noted no incidence of pyelonephritis and a single case of hyperchloremic acidosis. In 1953 also, Brunschwig [29] described a single case with satisfactory results at the end of a one-year period.

Since the method necessitates an iliac colostomy, I have been somewhat reluctant to adopt it, feeling that the isolated ileal segment was probably easier to manage and possibly carried less risk of ascending infection. However, I have employed this method in three cases. One of them survived one year with normal upper urinary tracts and died of carcinoma. A second has survived more than three years, with normal pyelograms and no evidence of pyelonephritis but with a mild degree of acidosis. The third was a case of bladder exstrophy, a failure following ureterosigmoidostomy by the Coffey I method, with complete destruction of the left kidney and marked hydronephrosis and hydroureter on the right. Both ureters were reimplanted into the isolated rectosigmoid, and the child has done remarkably well for about one year. Although the left kidney has remained functionless and has developed a calculus, the right kidney has definitely improved, so that the nonprotein nitrogen is now within normal limits. The child continues to have rather severe hyperchloremic acidosis, but she has gained weight and shown marked clinical improvement.

In my opinion, this procedure warrants serious consideration. It seems to be of particular value in those cases of recurrent clinical hyperchloremic acidosis which are difficult to control by simple means, and in cases of recurrent pyelonephritis in which no demonstrable obstruction can be found at the site of anastomosis.

ILEAL SEGMENT BLADDER SUBSTITUTION

Ileal segment bladder substitution consists of implanting the ureters into a segment of ileum isolated just proximal to the ileocecal valve. The value of the procedure lies in the fact that there is no stagnation of urine in the isolated segment, the segment simply serving as a conduit for transporting the urine into an ileostomy bag. Owing to intes-

‡ Mikuli,[16] cited by Hinman and Weyrauch.[1]

§ Rovsing,[24] cited by Hinman and Weyrauch.[1]

|| Schmieden,[26] cited by Hinman and Weyrauch.[1]

tinal peristalsis, there is never more than 15 to 30 cc. of urine in a properly constructed ileal segment. The principal advantages of the method, as pointed out by Bricker,[30] are reduced incidence of pyelonephritis and complete elimination of hyperchloremic acidosis.

This method was first described on an experimental basis by Mersheimer, Kolarick, and Kammandel.[31] However, they make no report of any clinical application of the procedure.

The largest series is that collected by Bricker, Butcher, and McAfee.[32] Most of their cases were in connection with pelvic evisceration, and their mortality statistics are considerably altered by the extensive nature of the surgery involved. They describe a series of 106 cases, 65 of whom survived six months or more. A study of follow-up pyelograms, ranging from 6 to 36 months, indicates a satisfactory result in 86% of the cases. Of 98 ureters which were normal preoperatively, 80% were classed as satisfactory at the end of six months. These authors also report that after surgery several cases displayed a marked decrease in preoperative hydronephrosis, accompanied by an improvement in renal function. Five of the 65 cases showed progressive hydronephrosis, in 2 accompanied by pyelonephritis. There was complete absence of hyperchloremic acidosis, and pyelonephritis was encountered in 11.5%. These results compare unusually favorably with most of the series in which careful follow-ups have been obtained after ureterosigmoidostomy with the intact colon. However, it must be emphasized that this operation is one requiring an unusual amount of surgical skill and that the series was compiled, for the most part, by surgeons of exceptional technical ability. It is doubtful whether many others will be able to duplicate their results, particularly during the early stages of developing their technique in this particular procedure.

Annis, Hunter, and Wells[33] present four cases, two with cystectomy for carcinoma of the bladder, one of tuberculosis, and one of multiple papillomata of the bladder. Their follow-up is for a short term, but they report a complete absence of complications.

Wilson[34] describes a single case of hyperchloremic acidosis, but it is notable in this instance that the kidneys functioned very poorly before operation and that acidosis was temporary, improving to the point where seven months later the patient had normal intravenous pyelograms with normal electrolytes.

My experience with this procedure has consisted of 41 cases. Four patients died in the immediate postoperative period, one of them surviving six weeks. Three of those who died had advanced carcinoma of the urinary bladder, and the operation was strictly a palliative measure to relieve intractable hemorrhage and urinary frequency. None of these three died of any complication referable to the surgery performed. However, because they did not leave the hospital, I am counting them as postoperative deaths. The fourth death was directly attributable to the surgery.

Of the 41 operations, 6 were performed for nonmalignant disease and 35 for carcinoma of the urinary bladder. There were no postoperative deaths in the nonmalignant group.

Immediate major postoperative complications consisted of wound dehiscence in four cases, intestinal obstruction in three, urine leak in two, and fecal fistula in one case. Delayed complications consisted of urinary sepsis in 12 cases, progressive hydronephrosis in 7, dermatitis in 7, and renal calculus in 1 case. The sepsis could be accounted for on the basis of an obstructive lesion in all but three (7%) of those cases in which this complication occurred. An over-all pyelographic analysis of 73 renal units on which adequate follow-up was available showed that 68.6% were acceptable and 31.4% unacceptable. However, if one eliminated those cases in which advanced renal disease existed prior to operation, 82% of the results were acceptable. In 12 cases with either advanced bilateral or unilateral renal disease preoperatively, there was such a marked improvement in function that 7

were considered as having normal upper urinary tracts postoperatively and the ultimate outlook for the other 5 was definitely improved.

In my experience, several advantages of this method have become apparent. There is no contraindication to the transplantation of widely dilated ureters. One is always extremely reluctant to transplant a fibrous dilated ureter into the intact rectosigmoid, and many postoperative difficulties with ureterosigmoidostomy occurred in that type of patient. However, with the ileal segment, the incidence of complications in transplanting a dilated ureter is no greater than that with a normal ureter. As a matter of fact, the technical procedure of transplantation is made considerably easier when the ureter is dilated. A second advantage is the relative freedom from hyperchloremic acidosis and repeated attacks of urinary sepsis. As noted previously, only 7% of those in whom no mechanical difficulty existed have had any urinary sepsis. Furthermore, in these cases the sepsis has been extremely mild and responded promptly to suitable chemotherapy.

It is my belief that ileal segment bladder substitution should be utilized in all young persons, in adults with nonmalignant disease, and in those cases of bladder carcinoma in which an above-average chance of cure is thought present. Obviously, it is the method of choice with pelvic evisceration when no rectosigmoid is available.

URETEROSIGMOIDOSTOMY IN THE INTACT COLON

Undoubtedly, uretosigmoidostomy in the intact colon is the most widely accepted procedure for urinary diversion. I shall not endeavor to discuss the merits of the various types of transplantation. The number of different types is almost as great as the number of operators carrying out the procedure. In the final analysis, the bulk of the operations are either modifications of the Coffey I tunneling procedure or the direct end-to-side anastomosis, or the "combined" method. The improvement in mortality statistics that occurred with the advent of chemotherapeutic agents and adequate bowel preparation is most impressive. In Hinman and Weyrauch's large collected series, operative mortality was about 15% for nonmalignant conditions and almost 50% for carcinoma. These statistics are verified by many others reporting over approximately the same period. Since 1936, operative mortality has been so reduced that even in series involving cancer it may be as low as 4.5% and is usually somewhere between that figure and 12%. This significant decrease has undoubtedly added considerable impetus to the utilization of the procedure.

Because it is difficult to separate the results of cancer surgery from those of ureterosigmoidostomy, I have divided the cases into two groups, those in which there was no malignant disease and those in which carcinoma was present.

On the nonmalignant group, several authors have collected long-term follow-ups from the literature. Perhaps the two most complete analyses are those of Governeur [35] and Stevens.[36] Since their reports cover approximately the same cases, Stevens' series is discussed. He collected 13 cases surviving between 20 and 43½ years postoperatively. In addition, he lists 27 patients in the 10- to 20-year survival group. However, many of his survivors must be classed as urologic cripples. Harvard and Thompson [37] describe a series of 144 patients from the Mayo Clinic that showed a five-year survival rate of 86.7%, reduced to 74.1% in 10 years and to 60.9% in 15 years. The number of cases involved beyond the 10-year period is too few to be statistically significant. Although the authors seem quite satisfied with the results, Creevy [38] points out that a death rate of 13.6% during the first five-year postoperative period is rather high. In all fairness, I think it should be emphasized that patients with exstrophy cannot be considered as normal persons and that many of them have abnormal upper urinary tracts prior to transplantation. Higgins,[39] in a series of 41 cases, had an operative mortality of less than 10%. Of the remaining 37 pa-

tients, 12 were alive five years or more and 6 survived more than eight years. Garrett and Mertz,[40] in a review of 11 cases followed 15 months to 33 years, found normal pyelograms in 74% of the cases and concluded that use of ureterosigmoidostomy for exstrophy was satisfactory. Jacobs and Stirling,[41] reporting on a collected series of 1673 cases, noted a 76.6% five-year survival among the cases of exstrophy and a 55.4% five-year survival in the group with vesicovaginal fistula. A compilation of all the cases recently reported shows 154 in which the results could be listed as good and 164 with a poor outcome.

As I noted previously, I have utilized the Boyce-Vest procedure for exstrophy in two cases. Three other patients have been treated for nonmalignant disease, all of whom were alive after five years. One has a normal upper urinary tract; one was lost to follow-up at the end of five years, and the third required reimplantation of both ureters into an isolated ileal segment because of progressive hydronephrosis.

Ureterosigmoidostomy seems to be the procedure most commonly used in exstrophy of the bladder. Because of late morbidity in persons who might have a right to a normal life expectancy, there is evidently considerable room for improvement in this field. Efforts are being made to preserve the urinary bladder and to establish sphincter control in these cases. Although a few encouraging results have been reported, the failure to establish urinary continence in the past makes one skeptical of the eventual outcome of these procedures.

With accompanying malignant disease, the results of urinary diversion are difficult to evaluate. As far as carcinoma of the urinary bladder is concerned, it is quite evident that in most instances cystectomy has been reserved either for those cases of carcinoma of the bladder in which all other means of therapy had failed or for those with the highly invasive sessile group of Grade 4 tumors involving the trigone and posterior wall of the bladder. Obviously, if one is to evaluate the results of any procedure on the basis of cases of this nature, the final conclusion will be a gloomy one.

Many fine articles have been written on late results following total cystectomy for carcinoma of the urinary bladder.

A number of excellent observers have expressed doubt concerning the efficacy of cystectomy. However, when one considers the dismal failure of so-called "conservative" treatment as presented by The Committee of Carcinoma Registry,[42] one must conclude that other methods have little to offer. Six hundred fifty-eight cases are analyzed and show a 23% survival at the end of five years. These figures are particularly significant when one considers that included in them was a survival rate of 45.9% for papillary carcinoma, Grade 1, a lesion which can hardly be regarded as a true carcinoma. Royce and Ackerman,[43] reporting 77 cases of tumors of Grade 2 or above treated by conservative means only, note a five-year survival of only 9%. If urinary diversion can be depended upon to give a patient a relatively comfortable existence for a 5- to 10-year period, in my opinion we are completely justified in recommending that procedure to any person with an operable malignant growth.

A recent article by Leadbetter and Clarke,[44] presenting a five-year survey of results following ureteroenterostomy by the "combined technique" is of interest. They report 40 cases, mainly of carcinoma of the urinary bladder. There was an operative mortality of 15%. They make no statement regarding the long-term follow-up for the carcinoma cases but do state that they consider 30 patients as having acceptable upper urinary tracts. These patients were observed for a sufficient period to permit an accurate evaluation of ultimate end-results.

In my own series, cystectomy with ureterosigmoidostomy was performed in a total of 70 cases. Of these, 28 are alive and 42 are dead. There was an operative mortality of 4.3%. Fourteen of these patients have survived five or more years, and one of them is in good health after seven years. The incidence of pyelonephritis has been 44%.

Of the deaths, the large majority were due to cancer. Although upper urinary tract disease may have been a contributory factor in the deaths of a few of these patients, in only two could the fatal outcome be attributed directly to the ureterosigmoidostomy. In a pyelographic analysis of 35 consecutive cases at the United States Veterans Hospital, Jefferson Barracks, Mo., 26% showed progressive loss of renal function and/or hydronephrosis. Pyelographic results were considered good in 63% and fair in 11%.

The following Table presents a summary of results following ileal segment bladder substitution and ureterosigmoidostomy. Since the Table covers my first two years' experience with the ileal segment bladder substitution, I am utilizing our published first two and one-half years' experience with ureterosigmoidostomy [27] for purposes of comparison.

Comparison of Ileal Segment and Ureterosigmoidostomy

Ileal Segment Bladder Substitution (41 Cases)	Per Cent	Ureterosigmoidostomy (54 Cases), Per Cent
Operative mortality	9	0 (5.4% in series of 92 cases)
Urinary sepsis	29	44
Progressive hydronephrosis	17	21
Dermatitis from ileostomy bag	17	0
Defective ileal stoma	9	0
Wound dehiscence	9	8
Intestinal obstruction	7	0
Urine leak	5	4
Renal calculus	2	2
Hyperchloremic acidosis	5	67
Acceptable postoperative pyelograms	68.6	63

From the Table it is readily apparent that the incidence of complications referable to mechanical errors during surgery is greater with ileal segment bladder substitution than with ureterosigmiodostomy. Furthermore, operative mortality is somewhat higher. In addition, the necessity of a mechanical device for collection of urine, with attending complications (17% dermatitis), must be given consideration. Balanced against these disadvantages are an almost total absence of hyperchloremic acidosis and a reduced incidence of urinary sepsis—two extremely important factors in considering long-term prognosis.

Since the five-year salvage rate in our series is only 32.6% for carcinoma of the urinary bladder, I believe that ureterosigmoidostomy is the procedure of choice in most of these cases.

COMMENT

From a review of all the recent literature on urinary diversion and from my own experience, several conclusions may be drawn. All patients with urinary diversion, irrespective of the type used, must have intelligent, careful follow-up attention at regular intervals for the rest of their lives. It is in this field that we surgeons have been most at fault. All too frequently, after the patient has been operated on and has gone home, we feel that he is cured and that no further observation on our part is necessary. In addition, unless the entire problem is carefully discussed with the patient, it is very difficult for him to realize the value of regular periodic examinations. Continued supervision will help to avoid many serious late complications. Early hyperchloremic acidosis, if recognized at the subclinical level, has required little treatment, and the patients have done quite well on simple therapeutic measures. An early progressive hydronephrosis which may subsequently lead to death of a kidney can and must be corrected by reimplantation. Repeated bouts of pyelonephritis with apparently good upper tract drainage following ureterosigmoidostomy call for diversion of the fecal stream by iliac colostomy, if ultimate renal destruction is to be avoided. The widespread condemnation of ureterosigmoidostomy is not justified in view of present knowledge and past experience. This method of diversion is still the most satisfactory in many cases. Cutaneous ureterostomy is attended with just as much upper tract morbidity as is ureterosigmoidostomy.

Finally, let us remember that, although we cannot expect normal upper urinary

tracts or normal longevity in the average patient in whom urinary diversion is accomplished by ureterosigmoidostomy or ileal segment bladder substitution, with a carefully performed operation and proper long-term management, a satisfactory result may be anticipated. There is great room for improvement in surgical management of carcinoma of the urinary bladder. This phase of management has lagged far behind the advances made in recent years in the field of urinary diversion.

SUMMARY

The most widely used methods of urinary diversion are reviewed.

I believe that the Boyce-Vest procedure for exstrophy of the urinary bladder has considerable merit.

Utilization of an isolated segment of ileum is the procedure of choice following pelvic evisceration. It may also prove to be the procedure of choice when extended longevity is anticipated.

Ureterosigmoidostomy is still the method of choice in many cases.

The importance of careful long-term management following any type of urinary diversion is emphasized.

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Surgery in Patients with Cirrhosis

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Within the past decade it has been found two of the chief causes of death in cirrhotic patients are partially amenable to treatment. Infection, which formerly killed approximately one-third of the patients with portal cirrhosis, can now be well controlled by antibiotic therapy. The incidence of exsanguinating hemorrhage from varices, which accounted for another third of the deaths in cirrhotic patients, has been lessened considerably by the development of various shunting procedures and direct surgical attack on the varices themselves. Hence, many cirrhotic patients may now be expected to live longer, ultimately developing other disorders which may require elective or emergency surgery.

Surgeons have noted that patients with unsuspected extensive liver damage often tolerate major surgical procedures well. More recently, patients with known liver disease and portal hypertension have successfully undergone a considerable amount of surgical trauma during shunting procedures. These recent findings suggest that we should reevaluate our concepts concerning the ability of such patients to withstand major surgical operations and disturbances in fluid equilibrium and shock and concerning the effects of these factors upon liver function.

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MATERIAL

Studies were made on a group of 37 cirrhotic patients—20 male and 17 female—who underwent surgery. Two patients were children, aged 18 months and 9 years; the remaining patients ranged in age from 31 to 69 years. In 21 patients the diagnosis of cirrhosis was not suspected at the time of the first operation. In the remaining 16 patients the diagnosis was made preoperatively. A total of 57 major operative procedures were done, 40 at the

TABLE 1.—*Nonsurgical Factors in Group I—Patients Dying Within Thirty Days After Operation*

Case	Sex	Age, Yr.*	Complicating Diseases	Jaundice		Ascites		Palpable		Cause of death
				History†	Examination‡	History†	Examination‡	Liver‡	Spleen‡	
1	F	42	Ulcerative colitis; hypersplenism; acquired hemolytic anemia	+	—	+	+	—	+	Coma
2	F	1½	.....	+	+	+	+	+	+	Coma, respiratory failure
3	F	33	.....	+	+	+	+	+	—	Coma
4	M	31	Acute nephritis	+	+	—	+	—	+	Hepatorenal failure
5	M	47	.....	—	—	+	+	—	—	Hemorrhage, coma
6	M	50	.....	+	+	+	+	—	—	Coma
7	M	58	Obstructed duodenal ulcer; arteriosclerotic heart disease with decompensation	—	+	—	+	—	—	Coma
			Total.....	5	5	5	7	2	3	

* Average age, excluding infant, 43.5 years.
† Within three years.
‡ At time of operation.

TABLE 2.—*Nonsurgical Factors in Group II—Patients Surgiving Surgery but Dead Within Two Years*

Case	Sex	Age, Yr.*	Complicating Diseases	Jaundice		Ascites		Palpable		Cause of death
				History†	Examination‡	History†	Examination‡	Liver‡	Spleen‡	
1	F	62	Diabetes; arteriosclerotic heart disease	—	—	—	—	—	—	Coma
2	F	40	Hemochromatosis	+	+	—	+	+	+	Coma
3	F	65	Hypertension and congestive failure	+	—	+	+	+	+	Coma
4	F	57	Bronchopneumonia	—	—	+	—	—	—	Coma
5	M	43	Asthma; skin cancer; bladder cancer	—	—	—	—	+	+	Intra-abdominal hemorrhage, 4 days after surgical biopsy
6	M	38	.....	+	+	—	—	+	+	Hemorrhage
7	M	47	.....	+	—	+	+	+	+	Coma
8	M	60	Syphilis	+	+	+	+	—	—	Cerebral vascular accident
9	M	61	Carcinoma of prostate	—	—	—	—	+	—	Unknown
10	M	49	Dihydromorphinone (Dilaudid) addiction; bronchopneumonia	—	—	—	—	—	—	Coma
11	M	55	Arteriosclerotic heart disease; congestive failure	—	—	+	+	+	—	Congestive failure
			Total.....	5	3	5	5	7	5	

* Average age, 52.4 years.
† Within three years.
‡ At time of operation.

TABLE 3.—*Nonsurgical Factors in Group III — Surviving Patients*

Case	Sex	Age*	Complicating Diseases	Jaundice		Ascites		Palpable	
				History†	Examination‡	History†	Examination‡	Liver‡	Spleen‡
1	F	9	.....	—	—	—	—	+	+
2	F	37	.....	+	—	—	—	—	—
3	F	20	Renal calculi	—	+	—	—	+	+
4§	F	40	Obesity; varicose veins; acute cholecystitis	+	+	—	—	+	—
5§	F	44	Hydronephrosis; cholelithiasis	+	+	—	—	+	—
6	F	36	Post-traumatic epilepsy	+	—	+	—	—	—
7	F	69	Arteriosclerotic heart disease	—	—	—	—	+	—
8	F	52	Cholelithiasis; arteriosclerotic heart disease	—	—	—	—	+	+
9	F	54	Duodenal ulcer; healed tuberculosis; hypertensive cardiovascular disease	+	+	—	—	+	+
10	F	24	Acute alcoholism; acidosis; septic abortion	—	—	—	—	+	—
11	M	68	Hypertension	—	+	—	—	+	—
12	M	60	Arteriosclerotic heart disease; cholelithiasis; duodenal ulcer	—	—	+	—	+	+
13	M	39	Avitaminosis; hydronephrosis	—	+	—	—	+	—
14	M	44	Duodenal ulcer; gastritis; varicose veins	—	—	—	—	—	—
15	M	55	Obesity; cholelithiasis	—	—	—	—	—	—
16§	M	50	Pylorospasm; obesity; cholelithiasis; esophageal diverticulum	+	+	—	—	—	—
17	M	43	Staphylococcus peritonitis postoperatively	+	+	+	+	—	—
18	M	50	Obesity; diabetes	—	—	+	—	+	—
19	M	65	Syphilis; hypertension; renal lithiasis; benign prostatic hypertrophy; generalized arteriosclerosis	—	+	+	+	+	—
			Total.....	7	9	5	2	13	5

* Average age, 45.6 years.
† Within three years.
‡ At time of operation.
§ Cirrhosis followed damage to the bile ducts complicating cholecystectomy.

TABLE 4.—*Surgical Factors in Group I—Patients Dying Within Thirty Days After Operation*

Case	Preoperative Diagnosis	Operation	Duration	Anesthesia	Antibiotics*		Narcotics†	
					Preop.	Postop.	Preop.	Postop.
1	Subphrenic abscess	Exploratory laparotomy; liver biopsy	2 hr.	Local, nitrous oxide	P, S, C	P, S, C	M	D
2	Cirrhosis; hypersplenism; acquired hemolytic anemia; ulcerative colitis	Splenectomy	4½ hr.	Cyclopropane, ether	P	P	D	D
3	Bleeding ulcer	Exploratory laparotomy; liver biopsy	.....	Cyclopropane, ether	P	P	M	M
4	Cancer of pancreas	Exploratory laparotomy; liver biopsy	35 min.	Spinal	..	..	D	D
5	Xanthomatous disease	Exploratory laparotomy; liver biopsy	1 hr.	Ether	..	P, C	..	..
6	Cirrhosis	Exploratory laparotomy; liver biopsy	1 hr.	Spinal	..	..	M	D
7	Obstructed duodenal ulcer; cirrhosis	Exploratory laparotomy; liver biopsy; gastroenterostomy	1 hr. 55 min.	Cyclopropane, ether	P	..	Dil., M	Dil.

* P, penicillin; S, streptomycin; C, chloramphenicol (Chloromycetin); T, oxytetracycline (Terramycin); A, chlortetracycline (Aureomycin).

† D, meperidine (Demerol); M, morphine; Dil., dihydromorphinone (Dilaudid); Met., methadone; Pa., a mixture of the hydrochlorides of the opium alkaloids (Pantopon).

North Carolina Baptist Hospital. Patients undergoing shunting procedures for portal hypertension are not included in the present study.

The patients were divided into three groups. Group I (Table 1) consisted of seven patients who died within 30 days after operation and whose deaths were considered to be directly or indirectly related to the operative procedure.

Group II (Table 2) was made up of 11 patients who recovered from the operation but died within two years after surgery.

Group III (Table 3) consisted of 19 patients still alive at the time of this study (an average of 39 months after surgery).

ANALYSIS OF CLINICAL DATA

Group I.—The diagnosis of cirrhosis was made preoperatively in only three of the seven patients who died in the immediate postoperative period. The various preoperative diagnoses and other pertinent data are

TABLE 5.—*Surgical Factors in Group II—Patients Surviving Surgery but Dead Within Two Years*

Case	Preoperative Diagnosis	Operation	Duration	Anesthesia	Antibiotics*		Narcotics*	
					Preop.	Postop.	Preop.	Postop.
1	Carcinomatosis	Exploratory laparotomy; liver biopsy	1 hr. 25 min.	Spinal ethylene	..	P	M	D
2	Jaundice	Exploratory laparotomy; liver biopsy	25 min.	Thiopental, ether, nitrous oxide	P	A, C	D	D
3	Jaundice	Exploratory laparotomy; liver biopsy	.....	.....	..	..	..	..
4	Cystocele; rectocele; descensus uteri	Hysterectomy	2½ hr.	Cyclopropane, ether	..	P	M	M
5	Carcinoma	Exploratory laparotomy; liver biopsy	1 hr.	Spinal	C, T	C, T	D	D
6 Op. 1	Cholecystitis	Cholecystectomy	1½ hr.	Thiopental, ether, ethylene	..	..	M	Met.
Op. 2	Cirrhosis; possible obstruction	Exploratory laparotomy; liver biopsy	2 hr.	Thiopental, ether, ethylene	..	..	M	..
7 Op. 1	Cholecystitis; cholelithiasis	Cholecystectomy; appendectomy	1½ hr.	Cyclopropane	..	..	M	M
Op. 2	Cirrhosis; esophageal varices	Subtotal gastrectomy; gastroenterostomy; liver biopsy	5 hr.	Cyclopropane, spinal, ether	..	P	D	M
8	Cirrhosis; cholecystitis; cholelithiasis	Cholecystectomy; choledochotomy; liver biopsy	4 hr.	Spinal	P	A	..	D
9	Benign prostatic hypertrophy	Transurethral resection	.....	Spinal	..	..	..	..
10	Carcinoma of stomach	Exploratory laparotomy; liver biopsy	1 hr. 40 min.	Cyclopropane, ether	..	P	Dil.	Dil.
11	Cirrhosis	Herniorrhaphy	1 hr. 50 min.	Spinal	..	P	M	..

* For explanation of symbols, see footnotes to Table 4.

noted in Tables 1 and 4. Three patients had other major complicating diseases at the time of surgery (Table 1), namely, (1) acute nephritis, (2) pyloric obstruction with diminished cardiac reserve, and (3) ulcerative colitis, hypersplenism, and acquired hemolytic anemia. The presence of cirrhosis was recognized preoperatively in two of these patients. Five of the seven patients in Group I gave a past history of jaundice, and five had a history of ascites. One patient had jaundice without ascites, and one had ascites without clinical jaundice. At the time of surgery all seven patients had ascites and five were jaundiced. Three had splenic enlargement, and the liver was palpable in two. Four patients received morphine before or after operation. A similar number were given antibiotics at some time during the preoperative or postoperative period.

The cause of death in every instance appeared to be hepatic insufficiency. Renal insufficiency was also present in one patient, and hemorrhage was a contributory factor in another.

Group II.—The diagnosis of cirrhosis was established preoperatively in only 2 of 11 patients who died after the immediate postoperative period but within two years after surgery (Tables 2 and 5). Five patients had a past history of jaundice, and five, of ascites; three had had both jaundice and ascites. At the time of operation three patients were jaundiced and five had ascites; two patients had both jaundice and ascites. Seven patients had clinical evidence of hepatomegaly, and five of the seven had palpably enlarged spleens. Each instance of splenomegaly was associated with hepatomegaly. In 8 of the 11 patients the operative diagnosis of cirrhosis was confirmed by biopsy.

In two patients malignant lesions were suspected prior to operation; in two the jaundice was thought to be due to posthepatic obstruction. Three patients had cholecystectomies performed for cholecystitis with cholelithiasis; of these, one was known to have cirrhosis. Three elective procedures were done—a herniorrhaphy, a transurethral resection, and a hysterectomy and vaginal repair.

Nine patients in this group had major complicating diseases, including diabetes and arteriosclerotic heart disease, hypertension with congestive failure, cancer of the urinary bladder, cancer of the prostate, syphilis, hemochromatosis, arteriosclerotic heart disease with congestive failure, and bronchopneumonia (two cases).

Five patients received antibiotics preoperatively, and eight, during the postoperative period.

Six patients in Group II died of liver insufficiency. In two death was attributed to cardiovascular disease. There were two instances of fatal hemorrhage—one from esophageal varices and another resulting from a surgical biopsy of the liver done four days prior to death. In one patient with a known prostatic carcinoma the immediate cause of death was unknown.

Group III.—The diagnosis of cirrhosis was made preoperatively in 11 of the 19 surviving patients (Table 3 and 6). In three patients the cirrhosis was secondary to biliary tract obstruction or to operations on the gall bladder and bile ducts. Seven patients in Group III had a past history of jaundice and five of ascites; two patients had both. Nine patients were jaundiced, and two had demonstrable ascites at the time of operation. The liver was enlarged in 13 patients, and splenomegaly was noted in 5.

The operative procedures are noted in Table 6. It will be seen that several patients had multiple operative procedures. The two patients with postoperative ductal strictures each underwent multiple attempts at relieving the biliary obstruction following the initial cholecystectomy. The 19 patients had a total of 37 surgical procedures necessitating general anesthesia.

Of the 19 patients, 17 had other major complicating diseases. There were three instances of cardiovascular disease, three of duodenal ulcer, five of chronic cholecystitis with cholelithiasis, two of renal stones, and one each of epilepsy, diabetes, and syphilis.

TABLE 6.—*Surgical Factors in Group III — Surviving Patients*

Case	Preoperative Diagnosis	Operation	Duration	Anesthesia	Antibiotics*		Narcotics*	
					Preop.	Postop.	Preop.	Postop.
1	Xanthomatous disease	Exploratory laparotomy; biopsy of liver and spleen; ligation of splenic artery	2 hr. 40 min.	Cyclopropane, ether	..	P	..	D
2	Cholelithiasis	Choledochostomy; liver biopsy	1 hr. 55 min.	Cyclopropane, ether, spinal	..	P	D	D
3	Renal calculi	Manipulation of ureteral calculus	20 min.	Thiopental	..	..	M	..
4 Op. 1	Umbilical hernia	Umbilical herniorrhaphy	2 hr.	Spinal	..	..	M	..
Op. 2	Acute cholecystitis	Cholecystectomy; accessory duct ligation	2 hr. 50 min.	Spinal, ether, cyclopropane	..	..	M	M
Op. 3	Plastic repair of common duct	Choledochoduodenostomy	3 hr. 30 min.	Spinal, ether, cyclopropane	..	..	M	D
Op. 4	Varicose veins	Vein ligation	2 hr.	Spinal	..	P	..	D
Op. 5	Stricture of common duct	Choledochojejunostomy	5 hr. 55 min.	Thiopental, ether	..	P, T	M	D
5	Obstructive jaundice; ? pancreatic carcinoma	Exploratory laparotomy; liver biopsy	2 hr. 15 min.	Thiopental, ether	P, S	P, S	D	D
6 Op. 1	Herniae	Herniorrhaphy	1 hr. 30 min.	Spinal	..	..	..	D
Op. 2	Herniae (recurrent)	Herniorrhaphy	2 hr. 5 min.	Spinal, nitrous oxide, cyclopropane	..	..	..	D
Op. 3	Ulcer	Subtotal gastric resection	3 hr.	Thiopental, cyclopropane, ether	P, S	P, S	M	D
7 Op. 1	Cirrhosis; hydronephrosis	Cystoscopy with retrograde pyelogram	35 min.	Spinal	..	..	M	D
Op. 2	Cirrhosis; hydronephrosis	Cystoscopy with retrograde pyelogram	1 hr.	Spinal	P	..	M	..
Op. 3	Cirrhosis; hydronephrosis	Left nephrectomy	.....	.....	..	..	..	..
8 Op. 1	Cholecystitis; cholelithiasis	Cholecystectomy; accessory duct drainage	2 hr.	Cyclopropane	..	..	M	D
Op. 2	Biliary fistula	Fistulogastrostomy	3 hr. 15 min.	Spinal	P	P, S	M	M
Op. 3	Stricture of common duct and transplanted fistula	Right hepatodochoduodenostomy	3 hr.	Nitrous oxide, ether, cyclopropane	..	A, P	M	D
Op. 4	Chronic hydronephrosis; chronic pyelonephritis	Right nephrectomy	1 hr. 15 min.	Thiopental, cyclopropane	S	S	Pa.	Pa.
Op. 5	Wound infection	Exploratory of wound and right upper quadrant	50 min.	Thiopental, nitrous oxide	P, S	P, S	Pa.	Pa.
Op. 6	Obstructive jaundice; cirrhosis	Exploratory laparotomy; liver biopsy	3 hr. 20 min.	Ether, spinal, cyclopropane	P, S	P, S	D	D
Op. 7	Cirrhosis; obstructive jaundice	Sympathectomy; splanchnicectomy; removal of celiac ganglion	2 hr. 40 min.	Cyclopropane, thiopental	P, S	P, S	D	D
Op. 8	Cirrhosis; obstructive jaundice	Plastic repair of common duct	7 hr.	Ether, thiopental, cyclopropane	P, S	P, S, T	D	D
9	Cirrhosis; varicose veins	Varicocelectomy; hydrocelectomy; vein stripping	1 hr. 58 min.	Spinal	..	P	D	D
10	Cirrhosis; pregnancy	Hysterotomy; bilateral salpingectomy	1 hr. 10 min.	Cyclopropane, ether	..	..	D	D
11	Cholelithiasis; cirrhosis	Cholecystectomy	1 hr. 25 min.	Cyclopropane, ether, thiopental	P	P	D, M	D
12	Cirrhosis, cholelithiasis	Cholecystectomy	.....	.....	..	..	..	..
13 Op. 1	Hepatitis	Exploratory laparotomy; cholecystectomy; choledochostomy	2 hr. 5 min.	Cyclopropane, spinal	..	..	D, M	D
Op. 2	Obstructive jaundice	Exploratory laparotomy; choledochostomy; sphincterotomy	3 hr. 15 min.	Spinal	..	S	M	D
14	Cirrhosis; cholelithiasis	Exploratory laparotomy; cholecystectomy; liver biopsy	1 hr. 35 min.	Spinal	..	P, S	D	D
15	Carcinomatosis; ? cirrhosis	Exploratory laparotomy; liver biopsy	1 hr. 20 min.	Cyclopropane, ether	..	P	D, M	..
16 Op. 1	Incarcerated incisional hernia	Repair of hernia	2 hr. 15 min.	Thiopental, cyclopropane	..	P, S	..	M, Pa.
Op. 2	Focal necrosis of colon	Suturing of necrotic bowel	45 min.	Nitrous oxide, ether	A	S	Pa.	Pa.
Op. 3	Obstructed duodenal; ulcer; ? obstructive jaundice	Subtotal gastrectomy; gastrojejunostomy; liver biopsy	5 hr. 15 min.	Spinal, nitrous oxide, ether	..	P, S	M	M
17	Cirrhosis; hernia	Herniorrhaphy	1 hr. 10 min.	Cyclopropane, ether	..	..	M	M
18	Cirrhosis; urinary retention	Transurethral resection; vasectomy; urethral dilatation	1 hr. 15 min.	Spinal	..	T	D	D
19	Incomplete abortion	Dilatation and curettage	15 min.	Spinal	P	P	D	..

* For explanation of symbols, see footnotes to Table 4.

TABLE 7.—*Summary of Laboratory Data*

Test	Normal Range	Group I Tests, No.			Group II Tests, No.			Group III Tests, No.		
		Done	Abnormal	Average Value	Done	Abnormal	Average Value	Done	Abnormal	Average Value
Total serum proteins	6.3 to 8.3 gm.	5	4	5.8 gm.	5	3	5.9 gm.	24	10	6.2 gm.
Albumin	3.6 to 5.6 gm.	5	4	2.9 gm.	4	4	3.0 gm.	20	7	3.7 gm.
Globulin	.....	5	..	2.8 gm.	4	..	3.0 gm.	20	..	2.7 gm.
Cephalin flocculation	<2+ in 48 hr.	1	1	...	4	3	...	10	9	...
Thymol turbidity	5 units	1	1	15.0 units	5	5	23.4 units	10	4	4.9 units
Alkaline phosphatase*	0 to 5.0 B.U.	2	1	7.9 B.U.	2	0	4.8 B.U.	8	7	18.0 B.U.
Van den Bergh	1.0 mg. or less	6	6	4.4 mg.	5	3	2.4 mg.	15	11	3.0 mg.
Sulfobromophthalein†	0% to 5%	..	..	...	3	3	34%	7	6	22.8%
Prothrombin time	<25% elevation	4	3	...	6	0	...	17	1	...
Hemoglobin	>11.5 gm.	6	4	9.6 gm.	8	4	12.0 gm.	25	6	12.9 gm.

* Bodansky units.
† No jaundice present.

Several patients had as many as three of the above-noted disorders.

Morphine was given preoperatively to 10 patients. Antibiotics were given to 7 patients preoperatively and to 14 postoperatively.

ANALYSIS OF CLINICAL FINDINGS AND LABORATORY DATA (TABLES 7 AND 8)

The incidence of palpable or enlarged livers varies among the three groups, and in a comparison of Groups I and III the difference in the number of patients found to have ascites at operation is statistically significant.

An analysis of the laboratory data, incomplete though they are, does reveal differences in the values for total serum protein and albumin among the three groups. The values for hemoglobin and prothrombin time show statistically significant variations when Groups I and III are compared.

Liver-Function Tests.—Since the diagnosis of liver disease was made preoperatively in only 16 of 37 patients and since some were operated upon elsewhere, surveys of liver function were not done in all cases. Where such data were obtained, however, the results are of interest (Table 7).

Group I: Six of the seven patients who died within 30 days after operation were jaundiced, and the average value of their van den Bergh tests was 4.4 mg. Determinations of the total serum proteins, albumin, and globulin were obtained in five of

TABLE 8.—*Comparison of Laboratory Data and Clinical Findings in Groups I and III*

Laboratory Data

Test	No. of Tests		Mean		Range		χ^2	Probability
	I	III	I	III	I	III		
TSP,* gm./100 cc.	5	24	5.8	6.2	4.7 to 7.2	4.8 to 7.9	0.78	<0.5 >0.3
Albumin, gm./100 cc.	5	20	2.9	3.7	2.0 to 3.6	1.8 to 4.9	2.16	<0.05 >0.02
Hemoglobin, gm./100 cc.	6	25	9.6	12.9	5.0 to 14.0	9.5 to 16.7	3.29	<0.1 >0.05
Prothrombin time	4	17	3 abnormal †	1 abnormal †	.....	.....	10.03‡	<0.01 >0.001

Clinical Findings

	Group I (7 Patients)	Group III (19 Patients)	χ^2	Probability
Jaundice	6	9	3.08	<0.1 >0.05
Ascites	7	2	18.09‡	<0.001
Hepatic enlargement	2	13	3.32	<0.1 >0.05
Splenic enlargement	3	5	0.65	<0.5 >0.3

* Total serum proteins.
† Elevated 25% over standard control.
‡ Statistically significant.

the seven patients in this group; four were below normal limits. A marked anemia was present in four patients. The average hemoglobin value for the entire group was 9.6 gm. per 100 cc. The prothrombin time was abnormally prolonged in three of four patients on whom the test was done.

Group II: In the 11 patients who lived for one month to two years after operation the decrease in serum protein levels, though present, was less marked than in Group I. The serum bilirubin was found elevated in three of five patients on whom a van den Bergh test was performed. Sulfobromophthalein (Bromsulphalein) excretion was studied in three patients, whose average retention at 45 minutes was 34%. In three of the four patients on whom a cephalin-flocculation test was performed, a 3+ reaction was obtained. Although four patients were anemic, the mean hemoglobin value for the group was 12 gm. per 100 cc. In no instance was an abnormal prothrombin time demonstrated, although this test was done on six patients.

Group III: Of the 19 patients still living after an average of 39 months after surgery, 9 were jaundiced clinically at the time of operation. The serum bilirubin was found elevated in 11 patients, the average value for those with jaundice being 3 mg. per 100 cc. Twenty determinations of the serum albumin were done in 16 patients; seven were below 3.5 gm. per 100 cc., and the average for the entire group was 3.7 gm. per 100 cc. Seven sulfobromophthalein excretion tests were performed in nonjaundiced patients, and abnormal retention of the dye was found in six. The cephalin-flocculation test was done in 10 instances and was abnormal in 9. Anemia was noted in six patients; the lowest recorded hemoglobin value was 9.5 gm. per 100 cc., the mean for the entire group was 12.9 gm. The prothrombin time was determined in 17 patients and was abnormal in only 1 instance. The alkaline phosphatase level was elevated in several of the patients in this group, a finding which is attributed to the number of patients having biliary duct damage (Table 6).

MEDICATIONS AND ANESTHETICS

The anesthetic agents used, in addition to spinal anesthetics, were cyclopropane, thiopental (Pentothal) sodium, ether, ethylene, and nitrous oxide. Except in four other cases (two given cyclopropane, one given ether, and one given thiopental sodium), the anesthetic agents were used in combinations. The patient who received only ether during a one-hour abdominal exploration died within the 30-day postoperative period. Cyclopropane was the principal anesthetic employed in 25 instances. Next in frequency were combinations of ether, thiopental sodium, and spinal anesthetics.

The part played by antibiotic therapy is difficult to assess. Antibiotics were administered to 14 patients preoperatively and to 26 postoperatively. The antibiotic most frequently employed was penicillin (11 patients) or penicillin in combination with other agents (10 patients). Streptomycin alone was given to three patients, and chlortetracycline (Aureomycin), to two.

Of 16 patients known to have cirrhosis, 9 were given morphine preoperatively.

COMMENT

The latency of cirrhosis is only too well illustrated by the failure to diagnose the condition preoperatively in more than half of the cases being reported. The marked regenerative ability of the liver frequently masks the presence of hepatic insufficiency until the disease is well advanced. The more frequent use of liver-function tests prior to surgical procedures will serve to detect many such cases. The importance of establishing the diagnosis preoperatively is obvious.

Evaluation of Liver-Function Tests

One must keep in mind when doing liver-function tests that not all of the multitudinous functions of the liver may be deranged and that the methods employed may

test only a few. In many instances a considerable degree of liver damage must be present to produce abnormalities of function which can be measured in routine laboratory determinations. Often certain functional activities of the liver are maintained at a relatively normal level, while others are considerably impaired. The dynamic aspects of function in the natural course of liver disease are not sufficiently emphasized.

In general, changes in function depend upon alterations in the parenchyma of the liver rather than upon fibrosis. The tests themselves are not specific for any particular type of disease. Repetition of the tests is necessary, and their diagnostic and prognostic value depends upon interpretation in relation to other findings and diagnostic procedures.

Certain generalizations may be made concerning the tests most commonly performed. A positive cephalin-flocculation test gives excellent correlation with the presence of inflammatory cellular disease. The determination of sulfobromophthalein excretion also serves as a valuable screening test, indicating parenchymal damage in the absence of jaundice. Another important test which is generally available is the determination of the prothrombin activity. When the latter is abnormal, the ability of the liver to respond to adequate amounts of parenteral vitamin K serves as an additional measure of function.

Although a variety of circumstances affect the total serum protein and serum albumin levels, marked changes are always associated with prolonged and severe liver damage. The lowest levels of albumin are invariably found in patients with ascites, and the importance of this finding has been established by numerous investigators.* The extravascular fluid spaces probably contain an amount of protein equal to that circulating in the blood and are a labile source from which the body can draw for the maintenance of homeostasis.[3] In cirrhotic patients with ascites both the blood proteins and the labile albumin stores are depleted. The loss of protein by hemorrhage or paracentesis aggravates the already existing deficit.

An analysis of the data reveals differences in the levels of total serum protein and albumin among the groups, the lowest values occurring in Group I. The difference between Groups I and III in the values for prothrombin times is sufficient to be statistically significant. In all patients tested, the sulfobromophthalein and cephalin-flocculation tests revealed evidence of moderate to advanced functional impairment; these values showed no correlation with the prognosis.

Although the utilization of these tests does not permit a complete evaluation of the functional state of the liver or the course of the disease in a given patient, the significance of the findings obviously bears a rough relationship to the degree of variation from normal.

Evaluation of Physical Findings

Clinical signs and symptoms are often unreliable in estimating the severity of hepatic injury.

A review of the literature reveals no unanimity of opinion as to the significance of liver size or jaundice.† It has been stated by some observers that the development of jaundice in a cirrhotic patient forewarns of early death, although occasionally it is recognized as an initial phase of liver injury.[6] From a review of the three groups studied here, it would appear that jaundice per se is not a factor in prognosis.

The findings of an enlarged liver have been noted by some writers to be associated with poor prognosis. Others have felt that the presence of spider angiomas, hepatic or splenic enlargement, and collateral circulation gives no indication of the degree of liver insufficiency.[7] According to one report, 25 of 44 patients with enlarged livers and clinical evidence of cirrhosis were found to have histologic evidence of fatty change in the liver. It would thus appear that patients with these clinical signs should be

* References 1 and 2.

† References 4 and 5.

given a more favorable prognosis, since this abnormality is more amenable to resolution without sequelae.[8]

In the present studies, also, the presence of palpable or enlarged livers (28.5% in Group I; 63.6%, in Group II, and 68.4%, in Group III) appeared to indicate a favorable prognosis.

The presence of ascites correlated with prognosis most significantly. It has been reported that 60% to 70% of patients with ascites will probably die within a period of 12 to 16 months.[9] The mortality figures are increased when such patients undergo surgery. Cates reported that 42% of such patients died within two weeks after omentopexy.[10] The serious prognostic import of ascites is borne out by our own data. All the patients who died within 30 days after operation (Group I) had ascites. Ascites was present in 46.4% of the remaining patients who died within two years. Of the patients still surviving, only 10.5% had ascites at the time of surgery.

Prognosis

While prognostic signs are not consistent enough to be trustworthy, the most significant and serious findings are ascites, hypoalbuminemia, prolongation of the prothrombin time, and anemia. Jaundice and derangement of the liver-function tests are of less serious import.

In a cirrhotic patient the finding of a palpable or enlarged liver is a more favorable sign than the absence of hepatomegaly.

With the occurrence of hemorrhage, the prognosis becomes poor. While the loss of blood may not be an immediate cause of death, the increased hypoproteinemia and anoxia may precipitate the development of ascites, jaundice, and coma.

Anesthesia

The liver—the largest cellular organ of the body except for the blood—has a high oxygen consumption. In spite of its large functional reserve capacity and remarkable powers of regeneration, it is most vulnerable to injury. Spinal anesthesia may produce alterations in liver function, particularly when it causes a fall in blood pressure.[11] Most anesthetic agents produce demonstrable alterations in liver function when anoxia is present. It has been demonstrated that nitrous oxide and cyclopropane tend to reduce the glycogen content of the liver, leading to an increase in blood sugar and glycogenesis.[12] Other experimental work, however, indicates that in patients with reduced liver function the use of cyclopropane with an adequate oxygen supply is the least harmful method of anesthesia.[13] It has been shown that the degree of glycogenesis present during cyplopropane anesthesia is decreased when an adequate supply of oxygen is given. Other observers, utilizing measurements of the bile salts in the urine, could demonstrate no harmful effects on liver function from the use of cyclopropane and nitrous oxide.[14] Ether, however, produced a marked disturbance by the same method of evaluation.[13]

A review of the data presented here reveals that, in spite of the failure in more than half the cases to recognize the presence of cirrhosis preoperatively, spinal anesthesia or cyclopropane was the predominant agent employed. Only one patient received ether alone, and this patient died within 30 days. With this possible exception, no correlation between the method of anesthesia and the period of survival could be noted in the three groups of patients.

In evaluating the effects of anesthesia, the magnitude of the operation as well as the type of anesthetic employed must be considered. Lengthy operations involving considerable loss of body heat, blood, and electrolytes, with associated circulatory disturbances, produce a greater change in liver function.

Opiates

It is generally recognized that in patients with liver damage the tolerance to morphine and other alkaloids is impaired. This fact has been demonstrated experimentally in both animal and human subjects. Liver dam-

age apparently inhibits the conjugation of morphine so that free morphine appears in the urine, even though there is no increase in the total amount of morphine excreted.[15] In spite of this knowledge, 9 of 16 patients in whom the diagnosis of liver disease was made preoperatively received morphine prior to operation, as a part of the "routine preoperative orders." From a review of the data, however, it cannot be shown that the administration of opiates had any significant effect upon the period of survival.

Antibiotics

It has been observed that some patients receiving chlortetracycline or oxytetracycline over a prolonged period (one to two months) may develop fatty infiltration of the liver.[16] It has also been suggested that chlortetracycline may influence favorably certain instances of chronic hepatitis and hepatic coma.[17] Of the cases here reported it may be said that in no instance was antibiotic therapy prolonged to the point where any histologic change might be anticipated and that no untoward effects which could be attributed to such therapy were noted. A review of the individual cases revealed no instance in which the use of antibiotics was followed by a beneficial change of sufficient degree to be attributed to the antibiotic. Although available clinical data would appear to indicate that chlortetracycline is the agent of choice in patients with liver damage, penicillin continues to be used more commonly.

Conclusion

It appears that, despite the increasing emphasis on the diagnosis and management of liver disease, many cases go unrecognized and the patients are subjected to major surgery without the advantages of correct preoperative diagnosis and preparation. The belief that the cirrhotic patient is a poor surgical risk is well founded. Nevertheless, when the disorder is recognized and properly evaluated, when the patient is given the advantage of optimal preoperative preparation with adequate diet and restoration of the hemoglobin, protein, and electrolyte levels as nearly as possible to normal, when the analgesic and antibiotic agents to be employed preoperatively and postoperatively are judiciously selected, and when anesthetics providing adequate oxygenation are used, it should be possible for many patients with chronic advanced liver disease to undergo surgery with minimum risk.

Summary

Improvements in methods for controlling infection and hemorrhage have resulted in a more favorable prognosis for patients with cirrhosis. Many such patients now live long enough to develop additional complicating diseases which require emergency or elective surgery.

The marked latency of cirrhosis continues to present difficulties in diagnosis. Many cirrhotic patients are submitted to exploratory operations for presumed carcinoma or obstructive jaundice before definitive and accurate diagnostic survey have been performed.

The more frequent use of liver-function tests will serve to detect the presence of cirrhosis in the majority of cases. These tests, when interpreted in the light of physical findings and other accessory data, are of considerable diagnostic and prognostic value.

The signs of poor prognosis in cirrhotic patients are the presence of ascites, prolongation of the prothrombin time, and anemia. The additional findings of hypoalbuminemia and a small liver are also of serious import. Abnormal liver-function tests and the presence of jaundice are less significant.

In the absence of the more serious findings noted above, patients with cirrhosis are usually able to tolerate spinal anesthesia or cyclopropane with adequate oxygenation.

The routine use of unselected opiates before and after operation adds to the risk of surgery, and the incorrect choice of antibiotics may deprive such patients of the maximal opportunity for satisfactory recovery.

The data presented here and increasing experience would indicate that the properly selected patient with cirrhosis does not constitute an unfavorable surgical risk, provided the diagnosis is made in advance and proper precautions are taken before, during, and after operation.

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Metabolic Derangements Imperiling the Perforated Ulcer Patient

II. Derangements and Shifts of Intracellular Electrolytes; The Need for Potassium

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INTRODUCTION

The dehydration accompanying peptic ulcer perforation disrupts the normal distribution of electrolytes within the body. If ulcer patients are to be given the best opportunity to overcome their peritonitis, parenteral therapy must be based on an understanding of the ionic shifts involved. It is conceivable that hydration with fluids lacking the electrolytes of which the cells have been deprived may embarrass further an already burdened cellular metabolism.

To obtain insight into the fluid and electrolyte shifts between the cells and their environment, we have followed the changes in serum concentration and balances of the two major intracellular electrolytes, potassium and phosphorus.* It was of interest to see whether the two ions were handled by the perforated ulcer patient in the same manner, both being important to bodily function. Although both are intracellular, they differ in storage and in the number and nature of the metabolic processes into which they enter. Wide changes in the extracellular concentration of potassium in either direction are known to endanger survival. Little is known of the consequences of too low or too high a concentration of phosphorus in the extracellular fluid, yet phosphorus partakes in a number of vital processes, including the liberation of energy. Should the two ions be considered together in planning electrolyte therapy, or do they require independent management?

PLAN OF STUDY

The plan of study of the electrolyte shifts resulting from ulcer perforation had two parts: first, observation of the electrolyte changes resulting from ulcer perforation and customary methods of therapy, and, second, study of the effectiveness of deliberate efforts to diminish or prevent electrolyte losses.

Investigative Routine.—The main features of the investigative routine were described in the preceding paper.[1] Quantitative analyses of the potassium and phosphorus content of urine, feces, vomitus, and gastric drainage were made in the 12 cases with and 1 case without operation. Potassium outputs were measured in two additional cases with operation. For the first two or three days, urine specimens were collected at three- or six-hour intervals and the electrolyte content of each was measured separately. Thereafter, 24-hour specimens were analyzed.

Intake data were based in the case of intravenous feedings on careful volumetric measurements and in the case of oral food on weighed portions. The quantity of potassium and phosphorus in individual transfusion flasks was not determined. The volume transfused was measured accurately, and the amounts of the intracellular electrolytes were calculated on the basis of 192 mg. of potassium and 3

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* By the exclusion from our study of magnesium and other intracellular electrolytes we do not imply that they have no significance in the recovery from trauma.

mg. of phosphorus per 100 cc. of citrated whole blood. In charting the intakes, the red cell potassium and phosphorus were entered as if they were given as freely available electrolytes, since we do not know when they become available under traumatic conditions. The Sherman tables [2] were accepted for electrolyte content of food whenever they covered the type of food given. Additional information was drawn from the tables of Bowes and Church [3] or, in isolated instances, from food analysis in our own laboratory.

Supplementary potassium and phosphate ions were given to 5 of the 15 patients studied in an attempt to prevent development of intracellular electrolyte deficits. The composition of the solution used, hereafter referred to as K-B solution,[4] was as follows:

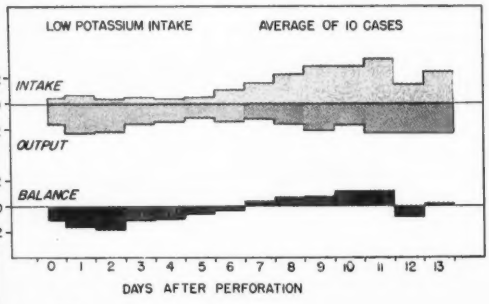
Potassium chloride	2.0 gm.
Anhydrous dibasic potassium phosphate	1.0 gm.
Sodium chloride	1.2 gm.
Sodium lactate	4.4 gm.
Water q.s. ad	100 cc.

TABLE 1.—*Electrolyte Composition of Parenterally Administered Solutions*

Solution	Potassium, Mg/100 Cc.	Phosphorus, Mg/100 Cc.	Sodium, Mg/100 Cc.	Chloride, Mg/100 Cc.
K-B solution	1,498	178	1,374	1,678
10% Amigen	30	90	150	200
Whole blood (85 cc.) plus preservative (15 cc.)	192	3	211	247

Thirteen patients were given one or more whole blood transfusions as needed to prevent shock and anemia, and in seven cases varying amounts of protein hydrolysates (Amigen) were given as part of the nitrogen study to be described in Paper IV of this series. The ionic compositions of the three solutions are found in Table 1.

Chart 1.—Pattern of initial potassium depletion and subsequent retention in patients on low potassium intakes (average of 10 cases). The return to positive balance was delayed until oral feedings increased the potassium intake. The excretion on the first and second days after perforation and operation was as great as it was later when positive balance was achieved.



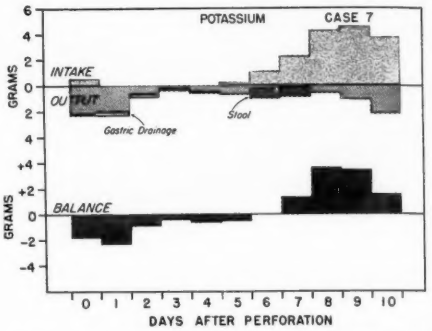


Chart 2 (Case 7).—Early potassium deficit and subsequent retention in a typical patient from whom supplemental potassium by vein was withheld. Despite the low intake, urinary potassium excretion was high during the first two days.

The total potassium intake during the first week averaged less than 1 gm. a day in six patients, 1 gm. or more but less than 1.5 gm. in four, and 1.5 gm. or more in five. The phosphorus intake was smaller: less than 0.3 gm. in five patients, 0.3 gm. or more but less than 0.5 gm. in five, and 0.5 gm. or more in four.

Methods.—Potassium was measured by the Perkin-Elmer flame photometer, checked by standard chemical methods. The concentrations of inorganic phosphorus were measured by the method of Fiske and Subbarow.[5]

POTASSIUM OBSERVATIONS

A. POTASIUM BALANCE

1. *The Initial Deficit.*—(a) Potassium Wasting in the Absence of Potassium Therapy: All 10 of the patients in whom no effort was made to maintain a high potassium intake exhibited an initial potassium deficit which lasted 4 to 10 days before positive balance was restored. The average was six days (Chart 1). Two factors contributed to the development of this deficit, the low intake itself and a sluicing of potassium through the kidneys in the first two days after perforation (Table 3). On those days an average of 59 mEq. of potassium poured out in the patients' urine, despite a reduction of their intakes to only 13 mEq. The largest daily output observed was 97.2 mEq. (3.8 gm.). In two cases the potassium outpouring was delayed 6 to 12 hours,

TABLE 2.—*Urinary Potassium Excretion in Healthy Patients on Various Potassium Intakes (Data from the Literature)*

Source, Ref. No.	No. of Patients	Period of Study, Days	Caloric Intake	Comment	Average K Intake/Day, mEq.*	Average Urinary K Output/ Day, mEq.*
9	2	56	2,500-2,800	.....	Not determined	82
8	2	5	1,600	†	69	64
8	2	2	800	After 5 days on 1,600 cal. and 2 days on 1,200 cal.†	36	42
8	2	2	400	After 2-day fast†	17	31
11	2	4	Not reported	After 2 days on reduced K intake†	10	32
10	2	4	Fasting	.....	0	43
8	2	2	Fasting	No previous dietary restriction†	0	37
7	1	4	Fasting	Last 4 days of 31-day fast	0	37
8	2	2	Fasting	After 6 days of reduced intake†	0	24
7	1	5	Fasting	First 5 days of 2d week of fasting	0	24

* Data in the literature reported in grams have been converted to milliequivalents.
† At bed rest.

TABLE 3.—*Urinary Potassium Excretion and Potassium Deficits in Perforated Ulcer Patients on High and Low Potassium Intakes (Data from This Series)*

No. of Patients	Average Caloric Intake, 1st Wk.	K Intake	Average K Intake/Day, mEq.				Average Urinary K Output/Day, mEq.				Total K Output/ Day, mEq.	Average Daily K Deficit
			Day 1 & 2	Day 3 & 4	Day 5 & 6	1st Wk.	Day 1 & 2	Day 3 & 4	Day 5 & 6	1st Wk.		
10	860	Low	13	13	21	19	54	33	28	33	41	22
1*	725	High	64	68	38	54	69	51	76	65	88	34
4	909	High	51	54	67	59	67	56	51	56	66	7

* Case without operation.

and in three others the first 3-hour collection showed a normal excretion rate, but in these last the admixture of urine formed before perforation may have been a factor. Once initiated, the outpouring in all these cases lasted approximately 48 hours, the duration ranging from 24 to 144 hours. By the third or fourth day after perforation and operation, potassium excretion had diminished, but the daily balance remained negative until the resumption of oral feeding increased the potassium intake. The balance of a typical case is seen in Chart 2.

(b) Diminished Depletion Resulting from Intravenous Potassium Administration, an Extravagant but Successful Therapy: The potassium deficit was diminished in all five of the cases given parenteral potassium therapy in spite of an augmented urinary spillage. During the first week after perforation, the average daily potassium output of the six patients receiving the lowest potassium intake (daily average of 10 mEq.) was 38 mEq. In contrast, the output of the three most intensively treated patients, on a daily intake averaging 66 mEq., was 69 mEq. (Charts 3 and 4). The patients on the higher intake thus excreted more potassium than the low-intake group, but their over-all negative balance amounted to only 3 mEq. per day as opposed to 28 mEq. in the low-intake group.

2. The Subsequent Potassium Retention.—In the potassium-treated patients the average potassium balance returned to persistent positivity by the fourth day after perforation. The average balance of the patients receiving no supplementary potassium became positive two days later, coincident with resumption of oral feeding and hence with increased potassium intake. After the seventh day the intake of the patients who had initially belonged to the low-intake group rose to equal or occasionally exceed

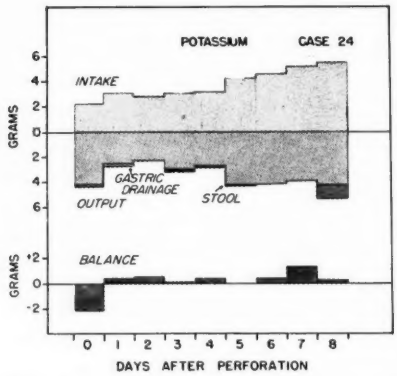
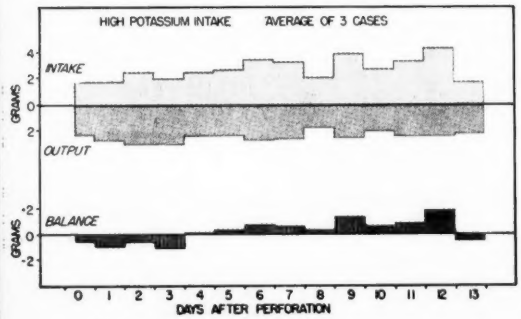


Chart 3 (Case 24).—Positive potassium balance achieved by intravenous potassium administration. A 4.4 gm. excretion on the day of operation resulted in a negative balance, but thereafter potassium depletion was successfully avoided by parenteral therapy. The serum potassium concentration was 3.6 mEq/L. preoperatively. With therapy it rose and was maintained above 4.1 mEq/L. for the next eight days.

that of the group previously on a high intake. Essentially the same pattern of potassium balance changes was observed in each group thereafter. In five patients potassium retention continued for several days until replenishment of the potassium previously lost had been achieved, and then the balance returned slowly toward equilibrium. In the remaining patients, the trend was in the same direction but the cumulative deficit had not been obliterated at the end of the study.

Chart 4.—Shortening of the period of potassium depletion by potassium therapy (average of three cases). Patients on low potassium intakes were in negative balance for six days on the average, as opposed to three days in this high-intake group. Compare with Chart 1.



Despite a better than average intake the single patient not operated on failed to show this period of potassium retention, maintaining a negative balance throughout his 11-day stay in the hospital.†

3. *Secondary Deficits As a Result of Complications.*—The development of complications interrupted the customary trend of balance changes in two of our cases. Initially, both followed the typical pattern, passing into negative balance after perforation and operation and reverting to positivity several days later. One of them, Case 8, returned to negativity on the ninth day, when he developed partial pyloric obstruction. Despite a diminished intake, output increased. This increase was due in part to resumption of gastric drainage, but urinary potassium output increased as well, presumably in response to the new stress (Chart 5 *A*). The second patient, Case 18, showed a similar deviation to negative balance on his 11th day while developing a subdiaphragmatic abscess. Transitory improvement after drainage of the abscess was accompanied by gradually diminishing negativity. Then, pyloric obstruction intervened. Potassium intake fell to zero, and the patient returned to a negative balance. With returning health after vagotomy, jejunostomy, and posterior gastroenterostomy, the patient finally began to regain his lost potassium (Chart 5 *B*). Positive balances due to whole blood transfusions are recorded on the days of operation.

Full balance data are not available on the other two patients developing complications.

B. Serum Potassium Concentration

1. *The Initial Normal Level.*—The serum potassium concentration was measured on admission in 17 patients and was within normal limits (3.5 to 5.0 mEq. per liter) in all but 1 (Chart 6). It was elevated only to 5.2 mEq. in the exception.

2. *The Subsequent Serum Potassium Change.*—During the first 24 to 48 hours after admission the potassium concentration

† The patient was returned to a penal hospital on the 12th day after perforation.

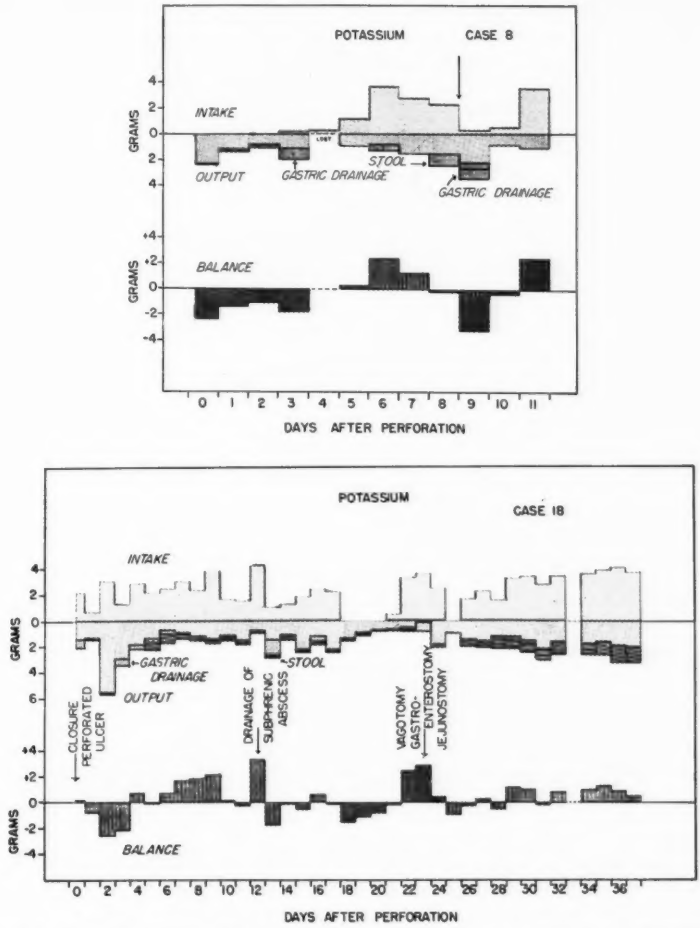


Chart 5.—Secondary potassium deficits accompanying the development of complications.

A (Case 8), patient showed a second increase in potassium output and a return to negative balance when he developed partial pyloric obstruction at the end of his eighth postoperative day. The long arrow indicates the time at which this complication was first recognized.

B (Case 18), patient exhibited negative balance on three occasions: on perforation, on development of a subdiaphragmatic abscess, and with the onset of pyloric obstruction. Each complication was treated surgically. The apparent positive balance on the days of operation is due to whole blood transfusion.

changes were of minor order, seven of the patients showing a slight rise averaging only 0.9 mEq. per liter. Then, as potassium depletion developed, the serum potassium began to fall, the magnitude of the depression depending on the potassium intake.

(*a*) Hypopotassemia in the Low-Intake Patients: The serum potassium dropped beyond the normal range to 3.5 mEq. or lower on the third, fourth, or fifth day after perforation in four of the six patients on the lowest potassium intakes (Chart 6). In three cases the level fell below 3 mEq. per liter. A wound dehiscence occurred in one of these three patients despite a high protein intake (Chart 7).

(*b*) Preservation of Normal Serum Potassium Concentrations by Intravenous Potas-

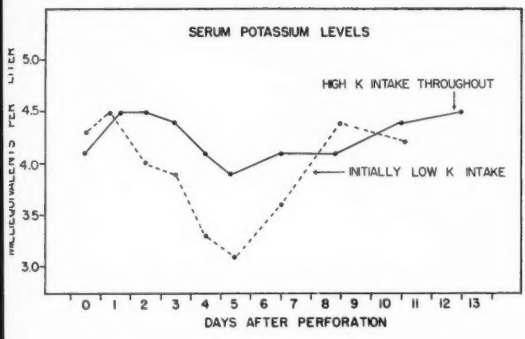
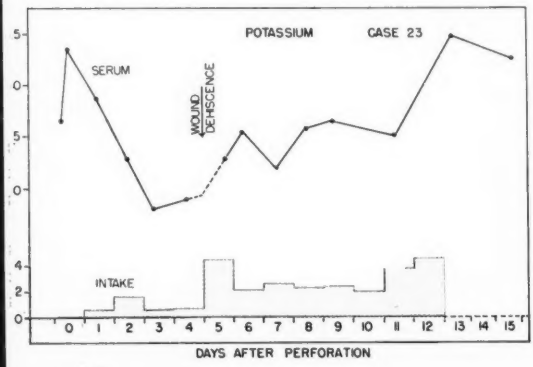


Chart 6.—The fall in serum potassium concentration associated with potassium loss. Average curves for patients on high and low potassium intakes are shown. The six patients in the group represented by the empty circles were initially given little potassium, but their intakes rose to approximately those of the three high-intake patients after the first week.

sium Administration: Although the serum potassium concentrations fell in the high-intake cases as well as in those with low intakes, no levels below the normal range were observed. The lowest concentrations were seen on the fifth day (Chart 6).

3. *The Late Restoration of Normal Serum Potassium Concentration.*—With the resumption of oral feeding, the hypopotassemia of the patients initially on a low intake disappeared. No subnormal levels were observed after the fifth postoperative day. Thereafter, the intakes and the serum potassium concentrations of the two groups were much the same. Adequate potassium ingestion led to a gradual rise in the potassium concentrations to levels near or a little above the concentrations observed on admission.

Chart 7 (Case 23).—Hypopotassemia associated with wound disruption in a patient on a low potassium intake. The patient, 55 years old, had wound dehiscence when his serum potassium level was 2.8 mEq/L. He was receiving a high protein intake at the time and had a serum protein concentration of 7.0 gm/100 cc. The possibility that he was overhydrated is suggested by the fact that he had received 16.3 liters of fluid in the first four postoperative days.



C. Potassium Concentration of Stomach Contents and Free Peritoneal Fluid

1. *The Elevated Potassium Concentration of Gastric Contents.*—Analysis of fluid obtained from the stomachs of 15 patients on admission revealed a potassium concentration 84% higher than that of the serum. The average gastric potassium concentration was 7.9 mEq. per liter, as opposed to the average serum concentration of 4.3 mEq. per liter. The highest gastric potassium concentration observed on admission was 13.9 mEq. per liter in Case 18. In only one case, Case 12, did the serum potassium exceed the concentrations in the gastric contents (serum K: 4.7 mEq.; gastric K: 4.1 mEq.).

2. *The Elevated Potassium Concentration of Peritoneal Fluid.*—Potassium concentrations of 8.1 to 10.1 mEq. per liter were measured in the small amounts (up to 410 cc.) of free fluid suctioned from the peritoneal cavities of four patients at operation. Traces of hemolysis were observed in this fluid, which may account for the observation of higher peritoneal than gastric fluid potassium.

Interpretation of Potassium Observations

A. Significance in Relation to the Plan of Electrolyte Therapy

In initiating these studies, it was hoped that some of the factors responsible for the high mortality rate in perforated ulcer patients might be exposed. The potassium observations fulfill that hope, revealing a potential hazard which is preventable. In other conditions hypopotassemia is known to have caused death by cardiac standstill, and, in addition, a whole gamut of symptoms varying from abdominal distention to ascending paralysis has been laid at the door of

serum potassium deficiency. In patients with perforated ulcers treated in accordance with current concepts, the serum potassium concentration fell, in some to subnormal levels. No subnormal serum potassium concentrations were observed in the patients given intravenous potassium therapy.

Eliel and associates [6] have made the interesting suggestion that potassium deficiency may be detrimental to wound healing. In our series only two wound-healing problems arose, one a dehiscence and one a partial separation (Cases 23 and 14). Both of these patients had low serum potassium concentrations at the time (2.8 and 2.6 mEq. per liter), but a third (Case 7) whose concentration fell to 2.7 mEq. per liter had no evident difficulty in wound healing. In the patient with the dehiscence, overhydration with resulting edema may have been partially or entirely responsible. His fluid intake during the first four postoperative days totaled 16.3 liters, the highest in the series. Three other patients with intakes nearly as high (14 or 15 liters over the initial four-day period) had no wound-healing problems. Our feeling is that numerous factors influence wound healing, and hypopotassemia may well be one. Hypoproteinemia is known to be another but can be ruled out in the case with the dehiscence, since this patient received the highest nitrogen intake of all patients studied and had a serum protein level of 7.0 gm. per 100 cc. on the day of his wound breakdown.

A study of the literature on the electrolyte excretion and balances of healthy subjects suggests that an inadequate potassium intake as well as an excessive postoperative potassium excretion were factors in the development of the potassium deficit in the ulcer patients. Selected potassium intake and output figures for healthy subjects taken from the works of Benedict,[7] Howard,[8] Dietrick,[9] Duncan,[10] and Black [11] are recorded in Table 2. From these figures it is apparent that as potassium intake is reduced the output decreases more slowly, resulting in a greater deficit the lower the intake. During the first week after perforation the average daily potassium intake of the 10 ulcer patients treated without supplementary potassium therapy was only 19 mEq., an amount insufficient to prevent potassium depletion even in normal subjects. Based on the data in Table 2 and other data not given,‡ their outputs should have been between 20 and 35 mEq. a day if the trauma of perforation and operation had had no influence on potassium excretion. Not until the third postoperative day did their outputs decrease to this expected level (Table 3). On the first two days the daily output averaged 59 mEq.

The data for the high-intake ulcer cases demonstrate that the initial potassium deficit can be diminished and a return to positive balance hastened by the administration of potassium (Table 3). It is possible to compensate partially for the potassium loss due to the excessive postoperative excretion and to eliminate the loss due to inadequate intake if enough potassium is given. Positive balance from the first postoperative day throughout the subsequent days of study was achieved in the last patient in the series. He was given the greatest amount of potassium (75 mEq./day) and was in negative balance only on the day of operation.

No undesirable effects of intravenous potassium therapy were observed. The potassium was given slowly and well diluted. Despite administration of amounts up to 107 mEq. on the first postoperative day and up to 203 mEq. (5.2 gm.) on subsequent days, no rise of serum potassium to a dangerous concentration was encountered.

Suggestions as to the quantity of supplementary potassium to be administered are presented in "The Plan of Therapy" given in Paper VI of this series.[12]

B. Significance in Relation to the Plan of Fluid Therapy

In Paper I[1] it was shown that the observed expansions of the thiocyanate and radioactive sodium spaces could not be satisfactorily explained by the fluid received as therapy.

‡ References 7 through 11.

If these expansions represented edema formation, the cells must have been called upon to supply the necessary water. The potassium observations show that if this withdrawal of cell water occurred, the dissolved electrolytes were not withdrawn in equal quantity. The thiocyanate expansions suggest withdrawal of nearly 5 liters of fluid from the cells of the average perforated ulcer patient (Section 5*C*, Paper I [1]). If this volume of fluid had left the cells together with the dissolved electrolytes, several hundred milliequivalents of potassium would have entered the circulation.§ The serum potassium concentrations of the patients should have shot upward or torrents of potassium poured out in the urine.

No such changes took place. The serum potassium rose in only seven patients, and the rise was minor (0.9 mEq/L.). Admittedly, the patients showed a potassium diuresis, but nothing of this magnitude. No patient excreted more than 179 mEq. between perforation and peak thiocyanate expansion. The average was 91.3 mEq. (Chart 3), and some of this potassium may have come from potassium infusions instead of from the cells. The average potassium intake before peak thiocyanate expansion was reached was 22.3 mEq. Case 10, who was in slight negative fluid balance at the time of an 11-liter thiocyanate space expansion,[1] showed a steady fall in serum potassium after admission and excreted only 79 mEq. (3.1 gm.) of potassium before peak expansion was reached (Chart 8). Similar observations were made in 12 other cases.

The quantity of potassium recovered in the urine and appearing in the serum of the patients studied suggests passage from the cells into the extracellular fluid of no more potassium than is present in a liter of intracellular water. The possibility that 5 to 11 liters of water leaves the cells accompanied by only a small amount of potassium raises a question as to the osmotic effect of the residual cellular potassium. In the patients studied, a rise in intracellular potassium of 10 to 100 mEq. per liter would have occurred as a result of cellular dehydration if the extracellular fluid had actually expanded as suggested by the sodium and thiocyanate measurements. It is questionable whether the cells could tolerate such increases, but intracellular hypertonicity cannot be used as a decisive argument against cellular dehydration, because it is possible that a mechanism of osmotic inactivation may exist. Potassium may combine with protein or some other large intracellular aggregate to diminish the effective ionic concentration.

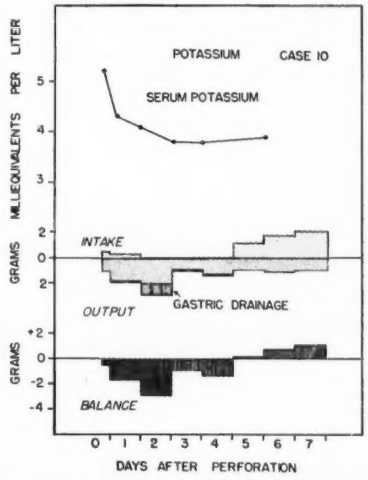


Chart 8 (Case 10).—Failure of the serum potassium concentration to soar or a flood of potassium to appear in the urine after perforation. This patient's thiocyanate space expansion exceeded his fluid retention by 10 liters. If that quantity of fluid had been withdrawn from the cells together with the dissolved electrolytes, 1500 to 1800 mEq. (59-70 gm.) of potassium would have been added to the circulation.

The possibility of transfer to the extracellular space of cellular water containing a reduced concentration of electrolytes is considered in Paper III of this series.[17]

In Paper III of this series,[17] more substantial evidence is given which discredits the hypothesis of a 5-liter extracellular expansion at the expense of cell water.

PHOSPHORUS OBSERVATIONS

A. Phosphorus Balance

1. *The Initial Deficit.*— (*a*) Phosphorus Depletion in the Patient with a Phosphorus-

§ On the basis of present-day knowledge, we can assume that cell water contains between 115 and 170 mEq. of potassium per liter. References 13 through 16.

TABLE 4.—*Urinary Phosphorus Excretion in Healthy Patients on Various Phosphorus Intakes (Data from the Literature)*

Source, Ref. No.	No. of Patients	Period of Study, Days	Average Caloric Intake	Comment	Average P Intake/ Day, Gm.	Average Urinary P Output/ Day, Gm.
8	2	5	1,600	.....	1.2	1.1
8	2	5	1,600	*	1.2	1.0
9	2	56	2,500-2,800	.....	1.5-1.6	0.8-0.9
10	2	6	1,200	After-4-day fast	1.6	0.9
8	2	2	800	After 2 days on 1,200 cal*	0.6	0.8
8	2	2	400	After 2 days on 800 cal (see above)*	0.3	0.7
8	2	2	400	After 2-day fast*	0.3	0.8
10	2	4	Fasting	.....	0.0	0.9
7†	6	4	Fasting	First days of prolonged fast	0.0	1.1
8	2	2	Fasting	First 2 days*	0.0	0.9
7	1	7	Fasting	Last week of 31-day fast	0.0	0.6
7‡	1	1	Fasting	Last week of 30-day fast	0.0	0.4

* At bed rest.
† Six cases summarized by Benedict,[7] including fasts of Levanzin, Succi at Florence and Hamburg, Beaute, Tosca, and S. A. B. All urinary phosphorus data given or cited by Benedict as P_2O_5 have been recalculated and are expressed in grams of phosphorus.
‡ Succi's Florence fast. Data taken from table by Benedict.[7]

TABLE 5.—*Urinary Phosphorus Excretion and Phosphorus Deficits in Perforated Ulcer Patients on High and Low Phosphorus Intakes (Data from This Series)*

No. of Patients	Average Caloric Intake	Phosphorus Intake	Average Phosphorus Intake/Day, Gm.	Average Urinary P Output/Day, Gm.	Average Total P Output/Day,* Gm.	Average Phosphorus Deficit/Day, Gm.
5	776	Low	0.1	0.4	0.6	0.5
1	725	Low	0.3	0.9	1.5	1.2
4	989	High	0.8	0.6	0.8	0.0

* Exclusive of losses from skin.

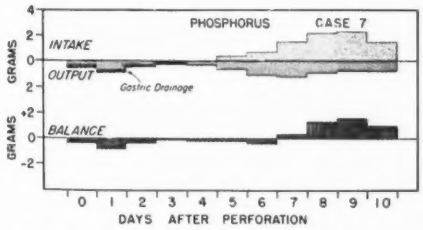


Chart 9 (Case 7).—Phosphorus intake, output, and balance in a typical patient on a low phosphorus intake. Positive balance was restored only after oral feeding was resumed, increasing the phosphorus intake.

Poor Intake: Phosphorus, like potassium, was excreted in greater quantity than received in the patients on low intakes. However, excessive excretion in comparison with the outputs of healthy subjects on similar intakes was fleeting. It lasted but 16 hours (range, 0 to 36 hours) in contrast to the 48-hour potassium diuresis. During this transient period of excessive excretion, outputs averaged 67 mg. per hour. For the remainder of the first two postoperative days normal outputs of 37 and 33 mg. per hour were observed (Table 4). Thereafter, subnormal outputs of 0.5 and 0.7 gm. per 24 hours occurred, persisting throughout the period of intravenous alimentation. Despite this low output, a deficit which lasted five to nine days developed in the seven patients in whom no effort was made to supplement the phosphorus intake. Chart 9 shows the phosphorus intake, output, and balance of a typical case. Average curves for five low-intake patients are given in Chart 10.

(*b*) Diminished Depletion Resulting from Intravenous Phosphorus Administration, an Economical Therapy: Administration of solutions containing phosphate ions to five patients reduced the average phosphorus deficit during the first few days and restored positive balance by the fifth day, as opposed to the eighth day for the low-intake cases

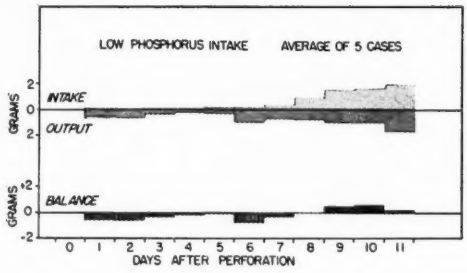


Chart 10.—Average phosphorus depletion in five patients receiving no supplementary phosphates by vein. Phosphorus depletion was due mainly to inadequate intake rather than to excessive excretion. Positive balance was restored by increasing the phosphorus intake when oral alimentation was resumed.

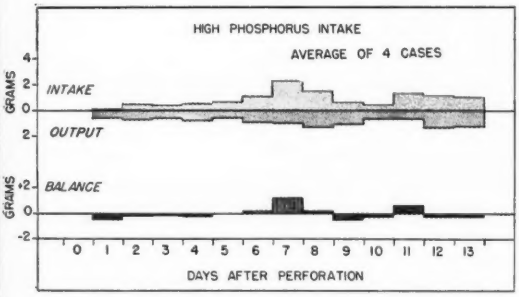


Chart 11.—Shortening of the period of postoperative phosphorus deficit by intravenous phosphate administration. Infusion of phosphate ions in these four cases increased slightly the phosphorus excretion, but much of the infused phosphorus was retained, diminishing the over-all phosphorus loss.

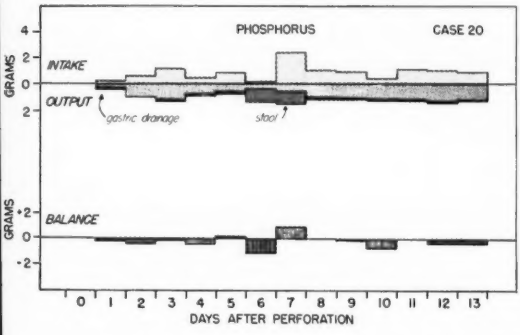


Chart 12 (Case 20).—Successful reversal of phosphorus balance by intermittent intravenous administration of phosphate. Phosphate infusions on Days 3, 5, and 7 increased phosphorus excretion only slightly or not at all, the major portion of the injected phosphorus being retained.

(compare Charts 10 and 11). Case 20 received sizable infusions of phosphate-containing solutions on the third, fifth, and seventh days after perforation and operation. The reduction in phosphorus loss and the swing toward phosphorus conservation on those days are shown in Chart 12. The phosphate infusions resulted in only slight increases in phosphate excretion.

2. *The Subsequent Phosphorus Retention.*—The return to positive phosphorus balance generally coincided with the resumption of oral feeding or with intravenous phosphorus administration. Phosphorus outputs rose as intakes increased, but the rise was not proportionate, intake increases outstripping the increase in output. In a quarter of the patients the previous cumulative deficit was wiped out by two or three days of phosphorus retention, and the day-to-day phosphorus balances then returned slowly toward equilibrium. In the remainder the deficit was not completely abolished before the end of the study.

The single patient not operated on lost phosphorus each day during his hospital stay despite an average phosphorus intake. His cumulative phosphorus loss at the time of discharge was 7.9 gm.

3. *Secondary Deficits As a Result of Complications.*—The customary pattern of change in the phosphorus balance was interrupted in two cases developing complications. A return to negative balance occurred in each case, the urinary phosphorus output increasing very slightly at the same time as the phosphorus intake fell off sharply (Chart 13).

B. Serum Phosphorus Concentration

1. *The Initial Normal Level.*—The serum concentration of inorganic phosphorus was measured shortly after admission in nine cases and was within normal limits (3.0 to 4.5 mg. per 100 cc.) in all but two. Levels of 2.4 and 2.8 mg. per 100 cc. were recorded in the exceptions. One of the two was receiving dextrose intravenously at the time the determination was made. Only one pa-

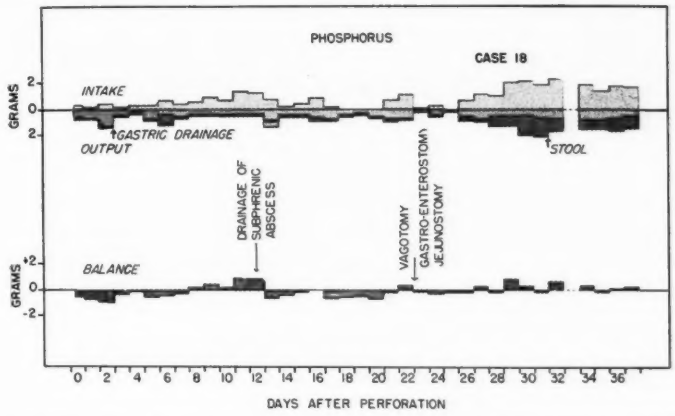


Chart 13 (Case 18).—Shifts in or out of phosphorus balance with improvement and deterioration of patient's condition. Secondary phosphorus losses followed drainage of a subdiaphragmatic abscess and recurred during the development of pyloric obstruction.

tient in the series had received an aluminum hydroxide preparation (Amphojel) prior to perforation, and this was not one of the two with hypophosphatemia.

2. *The Subsequent Fall in Serum Phosphorus Concentration.*—Measurements of the subsequent serum phosphorus concentrations were made at regular intervals in 11 cases. In 6 of the 11 a number of the determinations were made during or shortly after dextrose infusions. The levels varied irregularly in these patients. In the remaining five data free of this objection were obtained.

(*a*) Hypophosphatemia in Low-Intake Patients: Seven patients received less than 0.2 gm. of phosphorus a day during the first few days after perforation. Falls in serum phosphorus concentration to subnormal levels (2.4 to 2.9 mg. per 100 cc.) were observed in all but one. Three of these patients received intravenous dextrose before the low phosphorus concentrations were measured. The seventh patient, Case 10, despite dextrose infusions before each determination, showed persistently normal phosphorus concentrations.‖

(*b*) Preservation of Normal Serum Phosphorus Concentration by Phosphorus Administration: During the period that six of seven low-intake patients were hypophosphatemic, all four of the patients receiving 0.25 gm. or more of phosphorus a day maintained normal serum phosphorus concentrations.

3. *Late Restoration of Normal Serum Phosphorus Concentration.*—During the second week after perforation, fasting serum phosphorus concentrations were measured in six patients with uneventful convalescences. All but one of the determinations were in the normal range, and the exception showed only a minor downward deviation (2.9 mg. per 100 cc.).

The patient who developed the subdiaphragmatic abscess and pyloric obstruction exhibited unexpectedly high late serum phosphorus concentrations (Case 18). Between the 12th and the 25th days, when the patient's average daily phosphorus intake and output were 0.35 and 0.72 gm., respectively, five of nine serum phosphorus determinations were between 4.5 and 5.1 per 100 cc., the remainder being high normal. Two of the five high levels were obtained during fasting and the remaining three after meals or after intravenous dextrose.

‖ Concentrations above 4 mg/100 cc. were observed in four cases who had received intravenous dextrose, although in others levels as low as 1.7 mg/100 cc. were observed.

C. Phosphorus Concentration of Stomach Contents and Free Peritoneal Fluid

1. *The Elevated Phosphorus Concentration of Gastric Contents.*—Analyses for phosphorus were made on repeated samples obtained from 15 patients by gastric aspiration. On admission the gastric phosphorus concentrations averaged three and a half times greater than the serum levels (12.3 mg. per 100 cc. in the gastric fluid as opposed to 3.4 mg. in the serum). In the subsequent days the gastric phosphorus concentrations fell to below the serum concentrations in 9 of the 15 patients.

2. *The Elevated Phosphorus Concentration of Peritoneal Fluid.*—Fluid removed from the peritoneal cavity at operation was analyzed for its phosphorus content in two cases. In both concentration was more than four times that of the serum (serum concentrations: 2.8 and 4.4 mg. per 100 cc., and peritoneal fluid concentrations: 13.1 and 17.6 mg. per 100 cc.).

Interpretation of Phosphorus Results

A. Significance of the Observations in Relation to the Plan of Electrolyte Therapy

Little is known about the ill effects of phosphorus deficiency in man. In animals a multiplicity of symptoms and disturbances has been reported as the result of chronic phosphorus depletion. They include lacrimation, lassitude, weakness, polydipsia, difficulty in breathing, rarefaction of bones with disability on motion, formation of renal calculi, and elevation of the metabolic rate.¶ The lack of knowledge about the untoward effects of phosphorus depletion is in contrast to the abundance of information now available on the dangers and symptoms of potassium depletion.

It is possible that short-term phosphorus deprivation, such as a patient experiences postoperatively, produces no untoward effects. We were unable to correlate any undesirable clinical changes with hypophosphatemia in the patients studied. Nevertheless, after perforation the average patient loses a component of body tissue which could be economically saved, and, in the exceptional case, the additional depletion may be of significance. Perhaps the patient who has a phosphorus deficit prior to perforation due to prolonged aluminum hydroxide therapy fits in this category.

In our patients the phosphorus deficit was shown to be largely a matter of inadequate intake. The urinary phosphorus excretion of healthy persons on unrestricted diets is reported in the literature as close to a gram a day (Table 4).# Reducing the phosphorus intake to a third of a gram or even requiring the healthy subject to fast decreases the output only slightly, to 0.7 or 0.8 gm. a day. Fasting must be prolonged to diminish the phosphorus output further. Accordingly, in the ulcer patients on low phosphorus intakes urinary outputs of 0.7 or 0.8 gm. would have been expected were intake the sole factor in determining phosphorus excretion. Since an outpouring of the other major intracellular electrolyte, potassium, had been observed after perforation in all cases, a similar phosphorus diuresis was expected, whether due to excessive cellular breakdown or to hormonal influences associated with the alarm reaction. Phosphorus excretion increased, but only for a brief period. Although in six cases the potassium output was more than double that expected in normal subjects, in only two was the phosphorus output similarly increased. Furthermore, after the initial rise, phosphorus excretion fell to even lower levels than those appearing in the literature for healthy subjects during the first two weeks of fasting. In the first week after perforation the average daily urinary output for the low-intake cases was 0.5 gm. (total output, including stools and gastric drainage: 0.7 gm.). Excessive output thus played an insignificant role in the phosphorus depletion.

Administration of solutions containing phosphate ions to five cases diminished the phosphorus deficit, with only a trifling increase in phosphorus output. Whether the negative balances can be completely pre-

¶ References 18 through 20.

References 7 through 11.

vented by intravenous phosphate administration was not demonstrated. Case 20 (Chart 12) was shifted in and out of positive balance at will by increasing or decreasing his phosphorus intake. We believe, therefore, that balance could be maintained were it desired.

We have been unable to find in the literature any references to toxic reactions to administration of phosphate ions in the human being. No ill effects of phosphate administration were encountered in the cases studied despite infusion of as much as 3.8 gm. of phosphorus in the first 48 hours after perforation.

B. Significance in Relation to the Plan of Fluid Therapy

During the period between perforation and peak thiocyanate space expansion, falling serum phosphorus concentrations were the rule. In 11 cases for which data are available the average phosphorus deficit in the same period amounted to only 2.3 gm., an amount equivalent to the phosphorus in half a liter of intracellular water (Chart 14).*

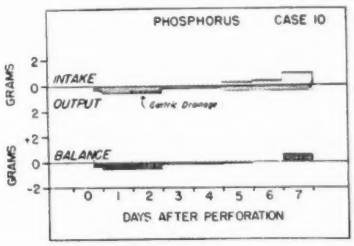


Chart 14 (Case 10).—Phosphorus intake, output, and balance of the patient who showed an 11-liter expansion of the thiocyanate space at a time that his fluid intake almost exactly equaled his fluid output (compare with chart 7 in Paper I[1]). Daily phosphorus excretion was 0.5 gm. or less throughout his hospital stay, and the patient's serum phosphorus level was only 3.7 mg/100 cc. at the time of peak thiocyanate expansion. Failure of the serum phosphorus concentration to soar or a torrent of phosphorus to appear in the urine lends support to the hypothesis that the extracellular fluid is not augmented by withdrawal of several liters of water from the cells.

In terms of the fluid needs of the perforated ulcer patient, the phosphorus data suggest that the migration of fluid from the cells to the extracellular space after perforation is not voluminous. However, the possibility that cell dehydration may occur independently of intracellular electrolyte depletion prevents us from drawing conclusions regarding the extent to which the cells are deprived of fluid. More definite conclusions can be drawn from the sodium and chloride balance data presented in the next paper of this series.[17]

* The concentration of phosphorus within the cells is reported as approximately 150mEq/L.[13]

Summary and Conclusions

The blood serum potassium level of patients with surgically closed perforated peptic ulcers falls if little or no potassium is included in the parenteral fluid therapy. It is postulated that hypopotassemia is one of the factors in the continued high mortality rate of ulcer perforation.

The fall in serum potassium results in part from distribution of potassium in edema water according to the laws governing ionic diffusion, but mainly from potassium loss through the kidneys. Patients to whom supplementary potassium is not given postoperatively go into and remain in negative potassium balance for almost a week.

Hypopotassemia can be prevented in perforated ulcer patients by administration of potassium by vein.

The postoperative potassium deficit is due to a combination of inadequate potassium intake and early excessive excretion. Potassium administered intravenously increases the potassium excretion, but if adequate amounts are infused the depletion can be prevented.

A deficit of phosphorus similar to the potassium deficit develops after perforation and surgical closure. It may be accompanied by hypophosphatemia. The consequences of this phosphorus depletion in man are not known.

Phosphorus depletion and hypophosphatemia can be economically prevented by intravenous phosphate therapy. The need for such therapy was not established.

A suggested program of fluid and electrolyte therapy for the perforated ulcer patient is given in Paper VI of this series.[12]

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Coronary Blood Flow in Hypothermia

Incidence of Ventricular Fibrillation with Decreased and Increased Coronary Flow

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Hypothermia as a valuable adjunct to intracardiac surgery has had two limiting factors which have interfered with its widespread acceptance. The relative frequency of ventricular fibrillation which may be irreversible and the short interval of safe blood-flow stasis have been the chief disadvantages observed in attempts to perform intracardiac surgery under hypothermia. The ventricular chambers are not accessible in the cold state, since ventriculotomy causes a very high incidence of fibrillation.

The cause of fibrillation is being vigorously studied in many clinics. Swan and his co-workers [8] have investigated the metabolic and electrolyte changes occurring at lowered temperature. Lange, Weiner, and Gold [5] found electrocardiographic changes in hypothermia suggestive of cardiac hypoxia. Penrod,[6] on the other hand, believed that oxygen utilization of the heart was normal at 20C, since he found no change in coronary arteriovenous oxygen differences from those in the normothermic animal. Coronary flow was not measured in these experiments; hence, no accurate calculation of oxygen consumption could be made. Studies from our laboratory [4] have indicated a definite and considerable decrease in coronary blood flow in hypothermic dogs, with a significant reduction in myocardial oxygen consumption in all experiments. An even greater proportional fall in left ventricular work was found, indicating a reduction in mechanical efficiency of the heart at lowered temperature. These studies also demonstrated that oxygen consumption of the whole animal was reduced to a greater extent than that of the heart during hypothermia, indicating that the heart maintains a relatively high oxygen consumption as compared with the rest of the body.

All previous studies on myocardial oxygen utilization in hypothermia have been carried out in animals without blood-flow stasis. We are reporting here attempts to evaluate the effect of decreasing and increasing coronary blood flow on the incidence of ventricular fibrillation in hypothermic animals and observations on one clinical case.

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METHODS

Mongrel dogs weighing 5 to 10 kg. were used in all experiments. They were anesthetized with sodium pentobarbital (30 mg/kg. intravenously) and cooled to a rectal temperature of 31 C by ice water immersion. After their removal from the water bath there was a further downward drift of body temperature to from 29 to 28 C, where it stabilized. Lung inflation was maintained by intermittent positive pressure through an endotracheal tube. No attempt was made to hyperventilate these animals. With clean but not sterile technique, the right chest was entered through the fifth intercostal space, the azygos vein was permanently ligated, and tapes were placed around the superior and inferior venae cava. At the conclusion of the period of cardiac exclusion, the chest was resutured and the dogs were rewarmed in a water bath at 42 C until body temperature reached 34 C.

INCIDENCE OF FIBRILLATION WITH REDUCED CORONARY FLOW

To investigate the incidence of ventricular fibrillation in hypothermia with severe reduction in coronary blood flow, the following experiments were performed. In 10 animals cardiac inflow stasis was produced for a period of 10 minutes by simply tightening the caval ligatures. As shown in Table 1, only one animal fibrillated and this occurred at the time of release of occlusion.

A second group of 10 dogs was cooled in the same manner, and both inflow and outflow occlusion of the heart were produced for a 10-minute period by caval occlusion plus clamping the aorta and pulmonary artery with a coarctation clamp inserted through the transverse sinus. Table 1 records

TABLE 1.—*Hypothermia with Inflow and Outflow Stasis (10 Minutes)*

Procedure	Number	Incidence of Fibrillation	% Mortality
Inflow only	10	1	10
Inflow-outflow	10	9	90

the results in this group, indicating that only one animal went through the occlusion and release without ventricular fibrillation. These findings confirm the work of Scott and his co-workers.[7]

To obtain a quantitative estimate of the amount of coronary blood flow under various conditions in hypothermic animals, another group of five dogs was cooled as above. A No. 14 Foley catheter with a 5 cc. bag was inserted into the right auricle through the auricular appendage and then into the coronary sinus. The balloon was inflated with 2 cc. of saline to obstruct sinus outflow except that through the catheter. The outflow end of this catheter was fixed at the level of the heart to prevent siphonage, and sinus flow was collected in a calibrated cylinder for a timed interval. Each animal was heparinized with 4 mg. of heparin sodium per kilogram of body weight. Outflow was collected for a complete 10-minute period (*a*) without blood-flow stasis, (*b*) with inflow stasis alone, and (*c*) with inflow and outflow stasis.

These studies on five dogs weighing 6 to 8 kg. revealed a total coronary sinus blood flow for 10 minutes of 30 to 50 cc. with inflow stasis alone. This is about one-fifth the blood flow from the coronary sinus over a 10-minute period which was found in the same hypothermic animals without stasis. It was observed that most of the measured quantity of blood flowing through the coronary circulation during inflow stasis appeared in the first 2 minutes, after which coronary flow was markedly diminished. With inflow and outflow occlusion, only 5 to 7 cc. of coronary sinus flow was measured in 10 minutes, which was undoubtedly drainage of blood which was present prior to occlusion.

INCIDENCE OF FIBRILLATION WITH INCREASED CORONARY FLOW

To investigate the tendency to fibrillation in hypothermic dogs with increased coronary blood flow, the following experiments were performed. Dogs were cooled as before, to a final temperature of 28 to 29 C. Arterial blood was collected in a glass reservoir from several unanesthetized donor dogs, with heparin as an anticoagulant. This reservoir was connected by Tygon tubing and a polyethylene catheter so that blood could be pumped centrally down one carotid artery by a Sigmamotor pump. One plastic catheter was inserted through the azygos vein into the superior vena cava and another through the right auricular appendage into the inferior vena cava for withdrawal of blood. These withdrawal catheters were led into a calibrated cylinder fixed slightly below heart level. The recipient dog was given a small dose of heparin (approximately 7 mg.) intravenously. The pump was started, and ligatures were tightened around the venae cavae to produce inflow stasis. It was found that, if the caval outflow catheters were correctly placed and not obstructed, outflow very closely approximated inflow from the pump, regardless of the rate of perfusion.

TABLE 2.—*Hypothermia with Inflow Stasis plus Arterial Perfusion (10 Minutes)*

Rate of Perfusion	Number	Fibrillation Stimulus	Incidence of Fibrillation	% Mortality
Control A no perfusion	10	Rt. Ventriculotomy	10	100
10 cc./kg./min.	10	Rt. Ventriculotomy	2	20
20 cc./kg./min.	10	Rt. Ventriculotomy; opening and closing septal defect	1	10

The stimulus for production of fibrillation in these experiments was either a standard right ventriculotomy alone or a ventriculotomy with production and immediate suture closure of a 7 mm. ventricular septum defect made with a Brock punch. It has been our experience and that of others that a ventriculotomy under hypothermia can occasionally be done without fibrillation and defects can be produced and closed if all trauma to the ventricle and septum is concluded within five or six minutes. A control series without perfusion was therefore carried out, in which a right ventriculotomy was performed with inflow stasis and the ventricle was left open for 3 to 4 minutes and then closed in leisurely fashion, concluding in 9 or 10 minutes. In this control series every animal fibrillated (Table 2), and it was observed that a majority of the arrhythmias occurred after 6 minutes, usually while the ventricular wound was being resutured.

A second series of 10 dogs was perfused with arterial blood at 10 cc/kg/min. via the carotid artery during inflow stasis. A right ventriculotomy was made and left open 3 to 4 minutes, then deliberately closed exactly as in the control series. Inflow stasis was maintained again for 9 to 10 minutes, and resuturing of the ventricle was completed immediately prior to release of the tapes. Table 2 indicates that only two dogs filbrillated, in each case as one of the initial traction sutures was being placed in the ventricular wall soon after caval occlusion. Another group of 10 hypothermic dogs was perfused with arterial blood at 20 cc/kg/min. during 9 to 10 minutes inflow stasis, and a ventricular septal defect was produced and sutured as added insult to the hypothermic heart. These defects were made in the muscular septum, away from the conduction bundle, to avoid artifacts from damage to conduction pathways. The results are presented in Table 2; only one animal suffered ventricular fibrillation; all other hearts beat regularly throughout the period of trauma.

It should be pointed out that these procedures were carried out as acute experiments, with no attempt at long-term survival; nevertheless, all dogs who lived through the period of cardiac stasis were resutured and rewarmed. Many of these dogs died a few hours later, apparently from intrapleural exsanguination, almost certainly from the effect of heparin, as no protamine was given. It should also be pointed out that there were no cases of coronary air emboli in these 10 dogs in which a ventricular defect was made and closed.

A final series of seven experiments was carried out aseptically, with a minimal amount of heparin in the donor blood (about 10 mg/liter), none in the recipients, and careful electrocoagulation of bleeding points of the wound edges.

These animals were cooled to from 28 to 29 C, as before. Inflow stasis was maintained for a total of 20 minutes while 10 cc/kg/min. of arterial blood was perfused down one carotid artery. The descending aorta beyond the left brachiocephalic branch was oc-

TABLE 3.—*Hypothermia with Inflow Stasis; No Cardiotomy (20 Minutes)*

Rate of Perfusion	Number	Incidence of Fibrillation	Permanent Survival
10 cc./kg./min. (descending aorta occluded)	7	2	5

cluded during this period, so that all perfused blood reached only the brain, heart, or upper extremities. No cardiotomy was performed. Five dogs survived the procedure uneventfully and were alive at the end of 2 weeks, when they were killed. One dog died of fibrillation which occurred immediately after release of occlusion, and another fibrillated after nine minutes of inflow stasis. No attempts were made to revert these cases of fibrillation with electric shock. It appears, therefore, that arterial perfusion can prolong the period of inflow stasis in hypothermic animals, with ultimate survival in a majority.

REPORT OF A CASE

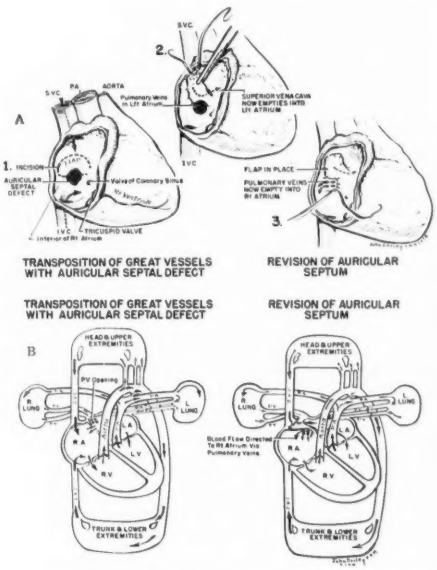
The following case is reported as our first attempt to use hypothermia plus arterial perfusion for prolonged open cardiotomy.

A six-week-old boy with severe cyanotic congenital heart disease was referred to Dr. Richard J. Bing. This child was cyanotic at birth, when he weighed 7 lb., and he had suffered several episodes of pneumonia, requiring hospitalization and oxygen. Frequent attacks of syncope occurred, and the baby lapsed into a lethargic semicomatose condition several days before he was first seen by us. Fluoroscopy revealed a very much enlarged heart with vascular lung fields and a narrow great vessel shadow on posteroanterior examination, which became broad on lateral view. A diagnosis of transposition of the aorta and pulmonary artery was made. The child's condition was obviously rapidly growing worse. It was decided to attempt a revision of the auriculum septum to reverse systemic and pulmonary venous inflow by the technique recently described by Albert.[1] This technique had been successfully carried out on a small number of hypothermic dogs with the aid of arterial perfusion in our laboratory prior to our seeing this baby. On Dec. 30, 1954, just 24 hours after the baby was first seen by us, surgery was undertaken.

Prior to operation 2000 cc. of venous blood from a total of four compatible donors was collected in a glass reservoir, with heparin, 20 mg/liter, as anticoagulant. Each donor's blood was cross matched with that of the baby and that of every other donor. The venous blood was oxygenated by bubbling oxygen gently through it for 30 minutes, at the end of which time it appeared bright red. The blood was kept at room temperature and was used approximately 5 hours after collection.

Under nitrous oxide-oxygen-ether anesthesia the child was immersed in ice water until his rectal temperature dropped to 88 F.

The heart was exposed by a transverse sternum-splitting incision extending out into both fourth intercostal spaces. The pericardium was widely opened, and the diagnosis of transposition of the great vessels was confirmed. Hernia tapes were passed around the superior and inferior venae cava. The azygos vein was permanently ligated. The right innominate artery was cannulated through the right subclavian for arterial perfusion, and the left innominate vein was cannulated for venous outflow. It would not be possible to run outflow catheters through the right auricle, as we had in the dog, since this would interfere with septal revision. The child was given no heparin. When all cannulas were in place, the venae cavae were occluded and the pump


TRANSPOSITION OF GREAT VESSELS WITH AURICULAR SEPTAL DEFECT
REVISION OF AURICULAR SEPTUM
TRANSPOSITION OF GREAT VESSELS WITH AURICULAR SEPTAL DEFECT
REVISION OF AURICULAR SEPTUM

Partial Correction of the Great Vessels by Auricular septum revision as described by Albert.

was started, with arterial perfusion at 20 cc/kg/min., or 62 cc/min. in this child weighing 3.1 kg. The heart, which had been very cyanotic, immediately became pink and beat regularly and strongly during the entire cardiotomy. The right auricle was opened through a longitudinal incision. There was a 2.0 cm. septal defect. The upper portion of the septum was cut posteriorly and superiorly, as shown in the Figure; a flap still attached anteriorly was fashioned, as described by Albert.[1] The septal defect left insufficient tissue for the formation of an inferior flap. The superior flap was sutured to the lateral and anterior wall of the superior vena cava, forming a tunnel to direct superior caval flow to the left auricle. The anterior edge of the septum was

sutured to the left of the four pulmonary veins; consequently, these vessels now emptied into the right auricle. Profuse coronary sinus blood flow plus regurgitation of arterial blood back through the aortic valve and the septal defect kept the operative field bathed in blood, despite intermittent obstruction of the ascending aorta with a Rumel tourniquet, and made the above tailoring and suturing more time-consuming than had been anticipated from our animal experience. Fifteen minutes had passed when this much surgery had been carried out, and so it was elected to close the auricle without attempting diversion of inferior vena cava flow. This could have been done with a small plaque of nylon cloth which had been previously prepared for use as a graft if there was a deficiency of auricular septum tissue, as was anticipated. The auricle was closed with a running stitch, and the caval ligatures were released after 19 minutes. Arterial perfusion was continued for one minute after release and then stopped. The heart continued its regular beat. A small tear had been made through the wall of the left auricle, and persistent bleeding into the left pleural space was observed that would not stop with pressure or an absorbable gelatin sponge (Gelfoam) pack. It was necesary to dislocate the heart to the left to secure this posterior tear with a single stitch. This dislocation produced ventricular fibrillation, which started 20 minutes after release of inflow occlusion. Cardiac massage followed by a series of three quick electric shocks did not stop fibrillation; so the pump was restarted and the heart was shocked again. Fibrillation promptly reverted to regular contractions with this second series of shocks aided by coronary perfusion. Cannulas were removed, and the incision was closed after careful hemostasis. The baby was rewarmed to 96 F in warm water and was returned to his crib. At this time he was moving spontaneously, was breathing well, and was observed to be much less cyanotic. He moved all extremities easily and cried weakly but never completely recovered from anesthesia. Six hours after operation respiration ceased before the heart, which was beating strongly and regularly a few minutes before death, stopped. Postmortem examination revealed a moderate amount of blood in both pleural cavities (about 150 cc.), which had not been removed by the catheters in each pleural space. Examination of the heart showed complete transposition of the aorta and pulmonary arteries, with a small patent ductus and the auricular septum defect previously described. Complete diversion of the superior vena cava into the left auricle by septal flap had been accomplished, as well as transposition of pulmonary venous drainage into the right auricle. A small septal defect remained, and the inferior vena cava still emptied into the right auricle.

It was our impression that this child died of cerebral anoxia, which was preesnt before operation but which may have been augmented by ligation of the damaged right innominate artery and by cerebral ischemia during the period of cardiac bypass. Encouraging to us was the fact that the defect was three-fourths corrected and that the heart withstood this 19-minute period of inflow occlusion so well. The ease of reversal of ventricular fibrillation by electric shock when the coronaries were being perfused was also very impressive.

COMMENT

The experiments were carried out to evaluate the effect of increasing or decreasing coronary blood flow on the incidence of ventricular fibrillation in hypothermia. There appears to be a definite increase in spontaneous fibrillation of the cold heart as inflow stasis is prolonged beyond 10 minutes. Scott and his co-workers [7] have demonstrated an increased incidence of fibrillation in a standard 10-minute period of caval occlusion if outflow stasis is added. Our experiments confirm their work very closely. It is unfortunate that occlusion of the aorta and pulmonary artery significantly shortens the safe period of stasis cardiotomy in hypothermia, since this technique has been the only successful means of preventing coronary air embolism. The reported evidence strongly suggests that reduction in coronary blood flow increases the incidence of ventricular fibrillation in hypothermia.

It is even more interesting that increasing coronary flow by arterial perfusion during hypothermia increases the resistance of the heart to ventricular fibrillation. This protection is not absolute, since the incidence of fibrillation in these experiments with increased flow was not zero. We do not believe that coronary flow is the only factor of importance in the cause and prevention of fibrillation. Undoubtedly there are electrolyte or metabolic changes that are important, as pointed out by Swan.[8] In other experiments, in which we attempted to slow the

heart rate of normothermic dogs by placing a small piece of ice on the sinoauricular node, fibrillation frequently occurred. This would be difficult to ascribe to either metabolic or coronary flow changes. Whether the increased incidence of fibrillation with decreased coronary flow is due to anoxia or to failure of removal of metabolic products is impossible to determine at this time.

Attempts at cardiac bypass with the aid of arterial transfusion have been reported by other workers. Berkas and co-workers [2] have studied arterial transfusion in normothermic animals as a means of permitting temporary cardiac inflow stasis. Survival up to 15 minutes was reported in several animals, with constant pressure as the perfusing force. Cookson and Costas-Durieux [3] studied the effects of arterial perfusion with a red-cell suspension in hypothermic animals and one clinical case, in an effort to combat coronary air embolism. A much smaller flow per kilogram per minute was used than in our experiments, and again the perfusion was by air pressure. We have used a greater volume of blood per minute than either of these groups of investigators and have elected to perfuse at a constant flow rate rather than at a given pressure.

Many facets of this problem need further delineation. Whether hypothermia is really necessary when the brain and coronaries are being perfused with fresh arterial blood needs careful study. Methods of further reducing the amount of heparin used as anticoagulant are being evaluated.

SUMMARY

For several minutes after vena cava occlusion in hypothermic animals there is a continuous, though small, back flow of arterial blood through the coronary circulation from the aorta. The incidence of spontaneous ventricular fibrillation is increased if this small coronary back flow is curtailed by occlusion of the ascending aorta during inflow stasis.

Hypothermic dogs can withstand right ventriculotomy and production and closure of a ventricular septum defect with a much lower incidence of fibrillation if coronary flow is increased by arterial perfusion with oxygenated blood.

Permanent survival was obtained in five of seven hypothermic dogs with inflow stasis for 20 minutes while the brain and heart were perfused with arterial blood.

Right auricular cardiotomy in a single human case with inflow stasis for 19 minutes is reported. This period of cardiac bypass was well tolerated by the heart, though the patient died later. Revision of the auricular septum for transposition of the great vessels was partially successful with use of the technique described by Albert.

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A New Technique for Thoracic Aortography Using the Right Supraclavicular Approach

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Recent advances in vascular surgery have made many previously hopeless lesions of the thoracic aorta amenable to surgical correction. A major need exists, however, for improvement in the radiologic visualization of suspected lesions of the thoracic aorta. The purpose of this paper is to present a new method for thoracic aortography, utilizing the right supraclavicular approach.

Although a number of techniques have been employed in performing thoracic aortography, none seems to be entirely satisfactory. Retrograde arterial catheterization and injection of a radiopaque dye via the carotid artery,[1] the radial artery,[2] or the femoral artery [3] often provide adequate visualization of the thoracic aorta but require operative arteriotomy and occasionally ligation of the vessel. Percutaneous parasternal aortic punctures are technically difficult and involve the risk of coronary perfusion.*

Recently Wickbom [6] reported a simple direct method of percutaneous aortic injection via a cervical approach, with the needle paralleling the right carotid artery. He reported a fatality, however, with this technique when the dye inadvertently was perfused into the coronary system as the tip of the needle lay in the ascending aorta.[7] This danger will exist so long as the needle is directed caudally into the ascending aorta. We have modified Wickbom's method in an effort to obviate the danger of coronary perfusion and in order to simplify thoracic aortic puncture.

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From the Department of Surgery, University of Colorado School of Medicine, and the Denver Veterans Administration Hospital.

* References 4 and 5.

ANATOMIC CONSIDERATIONS

The highest point of the arch of the aorta lies in the midsternal line 2.5 cm. below the jugular notch. This is the point of reference that we have employed in performing thoracic aortography from the cervical approach and represents the point of entrance of the needle into the arch. According to Wickbom's technique [6] the needle is placed through the skin just lateral to the sternocleidomastoid muscle, parallels the right carotid artery, and penetrates the ascending aorta, with the needle tip near the coronary ostia.

By inserting the needle above the right clavicle in the midclavicular line and directing it to the left and downward, it meets the apex of the aortic arch at its broadest point, enters the lumen in the direction of blood flow, and, if advanced, will traverse the lumen of the vessel and lie at the top of the ascending limb of the aorta (Fig. 1).

TECHNIQUE

The patient is placed in the dorsal decubitus position with his head turned to the left (Fig. 1), and a scout film is taken of that portion of the thorax under suspicion. The skin of the right side of the neck and right supraclavicular region is aseptically prepared and draped. A skin wheal of 1% procaine hydrochloride (Novocain) is then raised in

Fig. 1.—Position of needle in thoracic aortography. Upper needle: Wickbom's technique, with needle paralleling the right carotid artery and entering the ascending aorta with consequent danger of coronary perfusion. Lower needle: Our technique, indicating aortic puncture at the arch.

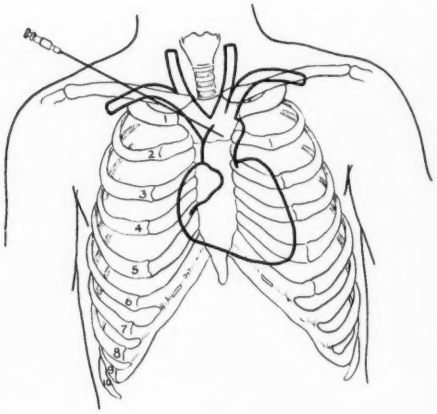


Fig. 2.—Diagram of anatomic position of aortographic needle, indicating point of skin puncture in right midclavicular line and point of entrance of needle into the arch of the aorta, directed toward the descending aorta away from the coronary and cerebral vessels.

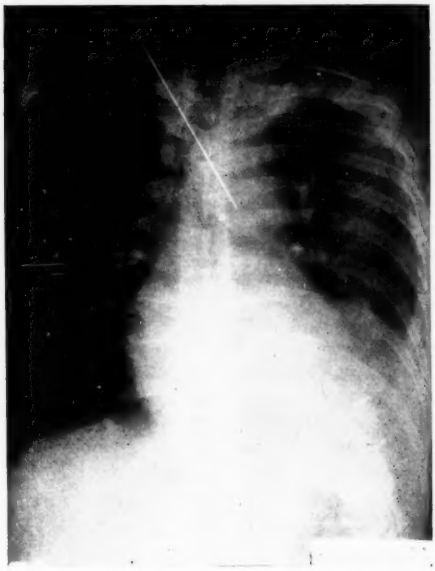
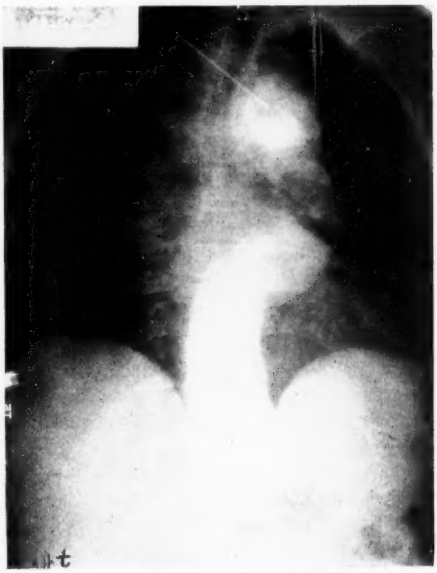


Fig. 3.—X-ray showing position of needle in arch of the aorta prior to injection of radiopaque dye.

Fig. 4.—Thoracic aortogram showing needle in arch of aorta and visualization of tortuous and dilated thoracic aorta.



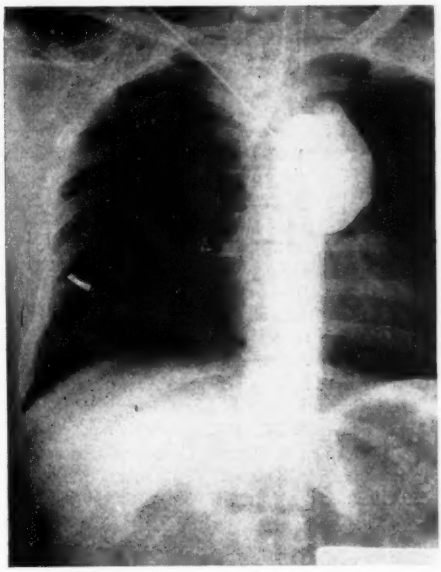


Fig. 5.—Thoracic aortogram showing aneurysm of aortic arch.

the right midclavicular line 1 cm. above the clavicle. A No. 17 short-beveled 15.4 cm. aortogram needle fitted with a stylet is then inserted through the skin wheal and directed medially, inferiorly, and slightly posteriorly, with the shaft aimed posterior to a point 3 cm. below the jugular notch in the midsternal line. This point represents the high point of the aortic arch, where the needle will contact the aorta (Fig. 2). The distance the needle must be inserted before it contacts the aorta can be measured by determining the distance from the wheal to the previously marked point in the midline, 3 cm. below the jugular notch. The needle may cross the apex of the right pleura but does not impale the lung. It is best not to withdraw the stylet until the needle is in the aorta, in order to avoid producing a pneumothorax should the needle inadvertently be in the pleural space. The aorta is so big at this point, the wall is so firm, and the transmitted pulsations are so characteristic that identification of the vessel is very simple. When the wall of the vessel is contacted, the needle is inserted into the lumen of the vessel by advancing it 0.5 to 1.0 cm. The stylet is then withdrawn, and a characteristic pulsatile ejection of arterial blood confirms the position of the needle. A short rubber adapter is fitted to the needle and attached to a 50 ml. Luer-Lok syringe filled with 30 ml. of a 70% acetrizoate (Urokon) solution. The dye is then inserted as quickly as possible, in order to obtain a solid bolus of radiopaque material, and the films are taken as the last of the dye leaves the syringe. The patient may be instructed to hold his breath as the dye is injected, in order to minimize movement. We have on occasion left the needle in the aorta for several minutes, thus demonstrating that there is no reason for haste in performing the injection as long as the patient does not move. Normally the only subjective sensation is a dull substernal discomfort as the needle passes through the wall of the aorta.

RESULTS

We have to date employed this technique on four patients in whom we wished to visualize aortic lesions unapproachable by

Fig. 6.—Thoracic aortogram showing postoperative homograft replacement of traumatic aneurysm of lower thoracic aorta.

the usual lumbar aortographic techniques. In each case we have found the technique to be simple and safe and to give good radiographic visualization of the thoracic aorta (Figs. 3, 4, 5, and 6).

SUMMARY

A technique of thoracic aortography is described which uses percutaneous injection of the aortic arch from the right midclavicular line above the clavicle.

The advantages of this technique over other procedures are described and illustrative cases presented.

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Intraluminal Resection of Esophageal Strictures

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The ideal treatment of stricture in the esophagus due to saponated cresol solution (Lysol) is, and will probably continue to be, early and regular dilatation until the situation is under control. However, there are, as every endoscopist knows, a certain few cases where this treatment fails, owing usually to late institution of therapy or failure on the part of the patient to follow through with regularity with his dilatations. Some of these failures are successfully handled by the thoracic surgeon; yet there remain a few cases where all of the conventional approaches fail for one reason or another. It is in this small desperate group of patients that the technique of intraluminal resection may make the difference between dangerous and not entirely satisfactory esophageal replacement surgery or a lifetime gastrostomy tube.

REPORT OF A CASE

A patient who fell into this latter class has been under intermittent observation and treatment at Strong Memorial Hospital for a period of eight years. In brief, the history was that of accidental ingestion of saponated cresol solution at one and one-half years of age. This was followed by dilatations, by both the endoscopic route and by the retrograde technique, for a period of six years. Two years ago an attempt at corrective surgery via the transthoracic route was made, and mediastinitis complicated the postoperative period. Dilatation by the endoscopic route was again started, but by Oct. 1, 1954, it was apparent that further dilatation would be futile. At that time there were two buttonhole strictures in the upper third of the esophagus which simply would not yield to further therapy. Because replacement surgery in a mediastinum which was known to have been involved in a purulent mediastinitis presented a decidedly poor field in which to operate and the fact that further dilatation was impossible, it was decided by the thoracic surgeon and the endoscopist to attempt the unorthodox approach to the problem, i. e., intraluminal resection of the two buttonhole strictures.

INSTRUMENTS

The first problem to be solved, once the decision to attempt intraluminal resection was made, was that of designing suitable instruments. Two were necessary: one, an esophagoscope that would allow fixation of the residual lumen at the strictural point so that it could actually be worked upon, and, two, a suitable knife with which the depth of incision could be accurately controlled.*

* The ribbon esophagoscope and esophageal resection knife are available to the profession through Welch-Allyn, Inc., Skaneateles Falls, N. Y.

Fig. 1.—The ribbon esophagoscope with proximal light trap and battery-containing handle.

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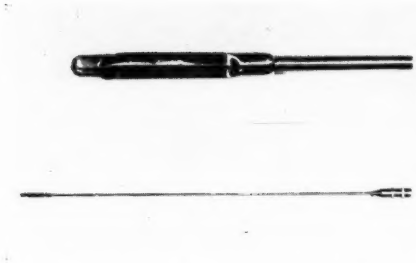

Fig. 2.—Esophageal resection knife.

The esophagoscope (Fig. 1) has a ribbon type of tube 30 cm. in length, 2 cm. in width, and 1 cm. in smaller diameter. The proximal end of the scope is enlarged to 2 cm. in diameter and is round to facilitate instrumentation and form a light trap, so that instrumentation can be carried out in a lighted room without interfering with the visual accommodation of the operator. To gain additional room the conventional light carrier is eliminated, and the current to the peripherally located light is carried in a tiny tube on the side of the esophagoscope. Power for illumination is supplied by batteries contained within the handle.

The esophageal resection knife (Fig. 2) is 36.5 cm. in length and consists of a handle, shaft, and blade imbedded in a small cylinder of steel 3 cm. in length and 3 mm. in diameter. This cylinder is rounded at the peripheral end to facilitate its passage through the stricture. One side of the cylinder is cut away in the middle two-thirds, and in this area the knife blade is exposed with a cutting edge of 1.5 mm. in depth and 1.6 cm. in length.

TECHNIQUE

The esophagoscope described above is first passed to the site of the stricture and the residual lumen fixed in a position so that it is roughly centered at the peripheral end of the scope. A light carrier from a conventional broncho- or esophagoscope is then passed through the opening in the stricture, allowing for retrograde transillumination of the stricture (Fig. 3*A*). Thus, the potential

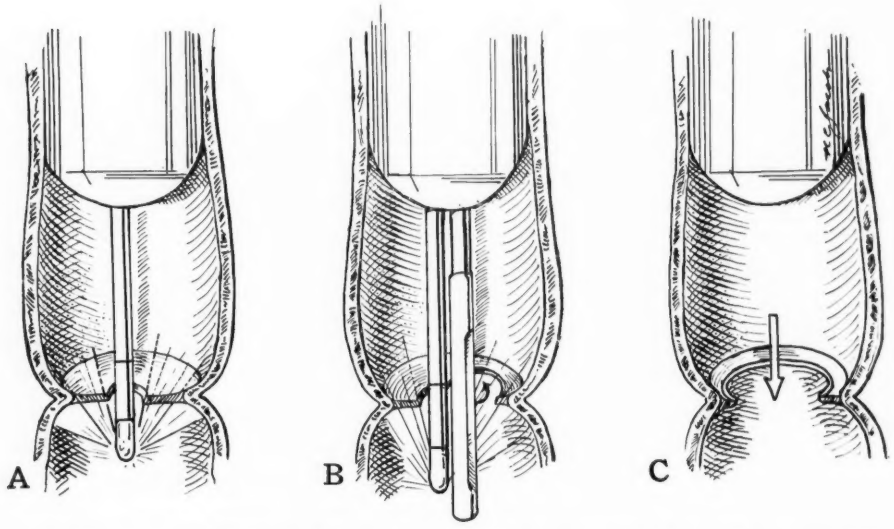

Fig. 3.—Diagrammatic drawings of the technique of intraluminal resection. *A*, the ribbon esophagoscope is advanced to a point of fixation above the stricture and a light carrier passed through the stricture for transillumination. *B*, the resection knife is then passed alongside the transilluminator and the incision carried to the desired depth. The edge of the incision is then scalloped as indicated by the arrow. *C*, this shows the relative size of recovered lumen after multiple resections to the normal lumen above and below the stricture site.

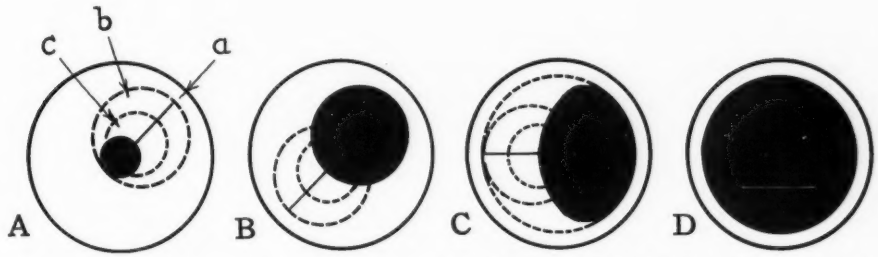

Fig. 4.—Schematic mapping of intraluminal resection of an esophageal stricture in three stages. *A*, the solid black dot represents the lumen of the stricture. The straight black line represents the incision. *B*, the black area represents the lumen present at the second instrumentation. The procedure is then repeated. *C*, the third and final resection. *D*, the solid black area represents the recovered lumen.

depth of incision into the stricture can be accurately judged.

The esophageal resection knife is then passed alongside the now indwelling light carrier, and by a saw-like motion the incision is carried to the desired depth. The mucous membrane and immediately submucosal scar tissue are then scalloped away from the proximal one-half of either side of the incision (Fig. 3*B*). This allows the residual lumen to widen and fall back toward (but not necessarily to) the normal esophageal wall above and below the stricture site (Fig. 3*C*). The wedges of removed mucous membrane and fibrous tissue allow for healing of the membrane over the edge of the exposed scar tissue before the cicatrix can reunite.

This procedure is then repeated two to four times on each stricture at 2-week intervals until a usable esophageal lumen is established (Fig. 4). The average has been three instrumentations. Each instrumentation has been immediately followed by bouginage to determine the relative release of strictural tension by sense of palpation.

COMMENT

The procedure described is frankly unorthodox. However, under the circumstances of the case in question, such an attempt seemed justified on two separate grounds. One, experience with dilatation of esophageal strictures had brought to light in the past one observation of importance, i. e., if dilatations are too strenuous, strictures sometimes rupture, and, if the patient survived the mediastinal emergency, further dilatation was seldom necessary. Two, the patient reported was known to have a "solidly frozen" mediastinum due to previous surgical complication, thus reducing the danger of further mediastinal difficulty to a minimum. Any other surgery carried a very real threat of fatal outcome, and a lifetime gastrostomy, the only other choice, in a 9½-year-old girl offered nearly as bad a prognosis as regards emotional and psychological outcome.

While the eventual outcome in the case presented will not be known until sometime in the future, the results thus far seem to justify this preliminary report. The last resection was done three months previous to the last endoscopic inspection. At this last inspection, the lumen was restored to useful size and there was no evidence of tendency toward reformation of the strictures resected. At the time of this instrumentation, a third but nonobstructive stricture was found just above the diaphragm. This could not previously be visualized, and, as it does not cause difficulty in swallowing, resection is not planned. At present the patient is enjoying solid food (bacon and hamburger) for the first time in her 9½ years of life.

One wonders if, with the antibiotics and chemotherapeutic agents available today, a deliberately induced, controlled mediastinitis, followed by intraluminal resection of esophageal strictures may not in the future shorten

the long and difficult course of some of these cases when the usual treatments have failed.

I feel obliged to warn the profession that instrumentation of this caliber would be highly dangerous in the hands of the occasional endoscopist.

SUMMARY AND CONCLUSIONS

A preliminary report on intraluminal resection of esophageal strictures is presented; a brief summary of the highlights of the case history of such a case is presented; instruments for intraluminal resection of esophageal strictures are described, and the technique of intraluminal resection of esophageal strictures is presented. A brief discussion of the problem, its handling, indications for intraluminal resection, and possible developments in the future are presented. Also, certain warnings as to dangers involved are given.

Esophagoscopy three months after resection showed the strictured area operated upon to be open and free of recurrence. Four months after resection was completed the patient was on a full diet.

A follow-up report will be presented at a later date.

Solitary Nonparasitic Cyst of the Liver

Review of the Literature and Report of Two Patients

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Sir Benjamin C. Brodie,[20] in 1846, described seeing a young lady with a cystic tumor of the upper right abdomen which disappeared after aspiration of 2 pt. of clear, watery fluid. This case has often been referred to in the literature as that of one of the earliest solitary cysts of the liver reported. Present-day diagnostic requirements would make it at least open to suspicion as a proved instance of solitary nonparasitic cyst of the liver. As time has passed, numerous reports of this entity have appeared, and it has become of greater interest. Recent technical advances in surgery of the liver should make such cysts easier to extirpate.

Wikle and Charache[135] state that the earliest reported case was that of Brisbane, on April 1, 1856, from postmortem findings. Review of this case leads me to believe that it was one of polycystic disease rather than a solitary liver cyst. Many authors state that Gloz[51] reported the first proved case in 1864. The present review of the literature reveals the first case to be that of Michel,[85] in 1856. This patient was a 60-year-old man with a large tumor in the region of the liver who died eight days after an attack of diarrhea. Autopsy revealed a cyst the size of a 4-year-old child's head on the concave surface of the liver and penetrating deep into the liver. It had a resistant whitish wall and contained yellowish-green fluid. Echinococci were searched for and not found. Ackman and Rhea,[2] in 1931, stated that 10 cysts of this type had been found in 6141 autopsies at Montreal General Hospital in the previous 24 years. Eliason and Smith[43] found only 2 patients listed in 211,046 admissions at Philadelphia General Hospital in eight years. In 20,000 autopsies in the same institution, 88 instances of nonparasitic liver cysts were found. This subject has been reviewed by Jones[64] in 1923, Orr and Thurston[97] in 1927, Stoesser and Wangensteen[122] in 1929, C. R. Davis[37] in 1937, and Eliason and Smith[43] in 1944.

Moschcowitz[90] was one of the first to consider the etiology of liver cysts. In 1906, he found 85 cases. These were instances of polycystic disease and were associated with similar disease in other viscera, most frequently the kidney. It was his belief that nonparasitic cysts of the liver were associated with congenital anomalies of the liver, arising in aberrant extrahepatic and intrahepatic bile ducts. He believed that these represented embryonal rests and that they only occurred in cystic disease of the liver and kidney. Nonparasitic cysts of the liver, in his opinion, originate in these aberrant ducts and are produced in two ways. They may arise from inflammatory hyperplasia of the ducts or by obstruction of the duct, retention of fluid, and the formation of cysts. Moschcowitz[90] saw no valid reason for believing such cysts to be true tumors. Norris and Tyson[95] concluded from studies made in infants with polycystic disease of the liver that the cysts are degenerative in type, arising from some abnormal extension of the process of resorption which occurs normally in the first generations of bile duct formed. More recently, Clagett[29] listed the hypotheses as to pathogenesis as (1) inflammatory, (2) degenerative, (3) tumor, and (4) developmental. C. R. Davis[37] was one of the first to divide these cysts into two groups, one representing polycystic disease of various viscera and the other, solitary cysts. Later writers have generally recognized this division. Frequent efforts

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have been made to classify solitary hepatic cysts. Sonntag,[118] Jones,[64] and C. R. Davis,[37] have all presented such classifications. Of these, that of Jones appears to have been more widely accepted by writers on this subject.

There is considerable confusion and much difficulty in determining the number of solitary liver cysts reported in the literature. A complete review of the literature was undertaken for this presentation. For the purpose of this review, however, an effort has been made to limit rigidly the accepted instances of solitary cyst of the liver as follows. The cyst must be single or at the most not occurring in more than two to three isolated portions of the liver. The gross pathological appearance must be rather typical, and the microscopic picture fit that as described by Schaack[112] and confirmed by others. The evidence for correct diagnosis as given by the author must be adequate to justify the diagnosis. If the report did not include sufficient evidence for one to be relatively certain of this, the case was excluded. No instance of polycystic disease is included. Cysts resulting from trauma, cystic formation of benign or malignant tumors, lymphatic cysts, dermoids, hemangioma, those following hemorrhage, and other types included in the usually accepted classifications are excluded in the review. It is believed that in this manner an accurate estimation of the number of solitary nonparasitic cysts of the liver can be determined. With these qualifications in mind, a review of the literature reveals 193 such cysts. These are presented in tabular form at the end of this paper.

This lesion occurs at all ages. Instances have been found in the fetus and newborn. Numerous cases have been reported in children. The oldest patient found in the literature was 82 years of age. Most patients have been in the fourth and fifth decades. Females are affected oftener than males, the ratio in the collected series being almost 4:1. The right lobe of the liver was involved approximately twice as often as the left. The cysts have varied in size from that of 3 cm., or a hazelnut or cherry, to those as large as a full-term pregnancy, as in a case reported by Stock,[121] or those filling the abdominal cavity, as described by Parry.[99] The contained fluid may be thin or thick and varies in color from a clear serous fluid to a typically bile-colored liquid. The quantity of fluid varies from a few cubic centimeters to 17,000 cc., as reported by Burch and Jones.[22] The fluid may contain albumin, protein and nonprotein nitrogen, mucin, chlorides, bilirubin, cholesterol, diastase, sugar, and epithelial debris. Specific gravity varies between 1.010 and 1.022.

Grossly, these cysts are usually rounded or ovoid in shape, well encapsulated and circumscribed and varying in color from grayish-white to yellowish or green. Often portions of the cyst can be shelled away from the surrounding normal liver. Numerous good-sized blood vessels extend into and about the cyst wall. Occasionally other organs may be loosely adherent to the cyst. Displacement of adjacent viscera by the tumor is common; especially is this true of the gall bladder, stomach, duodenum, and colon. The cysts, although solitary, may be multilocular. Schaack[112] has best described the microscopic picture. He states that the cyst is lined with cuboidal epithelium but that often the epithelial lining may be absent. He describes three layers of connective tissue making up the wall of the cyst: Numerous authors have confirmed this microscopic picture in its essentials.

Nonparasitic liver cysts present no specific symptom complex. Common in the list of complaints is a tumor or mass in the abdomen. Pain of various sorts, nausea, vomiting, and various forms of indigestion have all been described. Many patients present symptoms of pressure on adjacent viscera, with discomfort, intestinal obstruction, or the presence of blood in the stools. Frequently, the lesion presented in such manner as to appear to be an ovarian cyst. Physical examination usually reveals little but the presence of an abdominal tumor with occasional tenderness. Laboratory examinations seldom vary much from the normal. Radio-

graphic study shows only distortion and displacement of adjacent viscera, especially the gall bladder, stomach, duodenum, colon, and kidney. Torsion, strangulation, hemorrhage, and rupture have been reported as complications. In these instances, the symptoms and signs were essentially those of peritoneal irritation or of a ruptured viscus. The diagnosis is difficult to establish and has seldom been made prior to operation. Many of the reported instances have been found at autopsy and were not known to be present before death.

Surgical treatment has varied considerably. Aspiration, drainage, marsupialization, anastomosis to the intestinal tract, and complete excision have all been used. Excision or marsupialization appears to be the best methods of management. With present surgical techniques and methods, excision should be possible in most cases. Results have been good with few recorded recurrences. Few authors have discussed mortality. Beattie and Robertson [13] reported 13 deaths in 62 cases, a mortality of 20.9%. They stated that if the early cases which were only tapped are excluded this mortality is decreased to 16.1%. The present collected series reveals 10 deaths. Eight of these occurred in the immediate postoperative period; one, three weeks after leaving the hospital, and another, three months after operation. This brings the total mortality for the 193 patients in the series to 5.1%. If one includes only those cases reported from 1924 to the present, there are 3 deaths in 122 patients, or 2.4%. Six fatalities followed aspiration or drainage; one occurred after marsupialization, and three, after partial or complete excision. It would appear that in general the mortality should be low and the results excellent.

Abstracts of the clinical records of two patients successfully treated by me for solitary nonparasitic cysts of the liver are presented below.

CASE 1.—A 44-year-old white married woman was seen in consultation, because of a history of a tumor in the upper abdomen. Her history revealed that she had been treated in Jeanes Hospital in September, 1947, for a thrombophlebitis of both lower extremities. At this time there was no reference to a mass in the abdomen, but it was stated that her liver was enlarged downward for 5 cm. No other abnormalities were noted, and she made a good recovery. In November, 1947, she was readmitted with acute pain in the right abdomen, nausea, and indigestion. Examination revealed the same enlargement of the liver and some tenderness in the right thigh. Laboratory studies and x-ray examination of the gall bladder, kidneys, ureters, and bladder were reported as negative. Recovery was uneventful. The patient was again admitted in July, 1952, because of pain in the left lower abdomen of two weeks' duration. There was some backache but no other complaints. Past medical, family, and social history was irrelevant. Physical examination was normal except for the abdomen. The latter revealed a large freely movable tender mass occupying the right upper abdomen. It was about the size of a large grapefruit. All laboratory examinations were normal. X-ray study of the gall bladder was normal except for displacement of it medially. X-ray of the chest was negative. Intravenous urogram showed the right ureter to be deviated medially and slightly posteriorly from extrinsic pressure. The urinary tract was normal otherwise. The intravenous urography done in 1947 was reviewed and reported by the present examiner to show similar findings. Barium enema showed the hepatic flexure of the colon to be displaced downward, but the colon appeared normal otherwise. The displacement was interpreted as due to extrinsic pressure. The radiologist believed that a flat plate of the abdomen indicated that the mass was connected with the liver. The patient was subjected to laparotomy on July 22, 1952. Exploration revealed a rounded, soft, cystic mass, the size of a large orange, arising from the edge of the right lobe of the liver and the undersurface of the right lobe of the liver. It was reddish-yellow with several white patches on it and appeared to arise just beneath the capsule of the liver. The liver and gall bladder were otherwise normal, as were the remainder of the abdominal contents. The mass was easily excised from the liver, and the raw surfaces of the liver edges were sutured together over several pieces of absorbable gelatin sponge (Gelfoam) and the abdomen was closed. The patient made a completely uncomplicated recovery, with primary wound healing. The pathologic report was as follows:

"Gross Description: The specimen consists of a cystic mass of tissue more or less rounded and measuring 9 cm. in diameter. The surface is smooth on one side and rough on the other. The rough area corresponds to the area where it was attached to hepatic tissue. It is yellowish-brown in color and fluctuant. On opening the cyst, it is found to contain

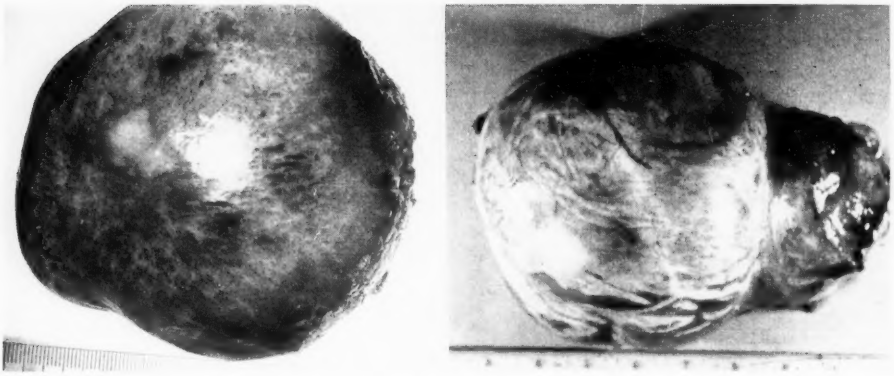


Fig. 1.—Photograph of gross specimens in reported cases. Case 1 on the left and Case 2 on the right.

350 cc. of an iridescent, yellowish fluid, somewhat viscid in character. The inner lining is smooth, shiny, and glistening. It is bluish-white and appears opaque. The specific gravity of the fluid was 1.020 and the pH 9.0. It was negative for bilirubin and glucose. It was positive for glycoprotein and mucoprotein and for albumin. Total proteins were 12 gm. per 100 cc. Microscopically it showed many cholesterol crystals.

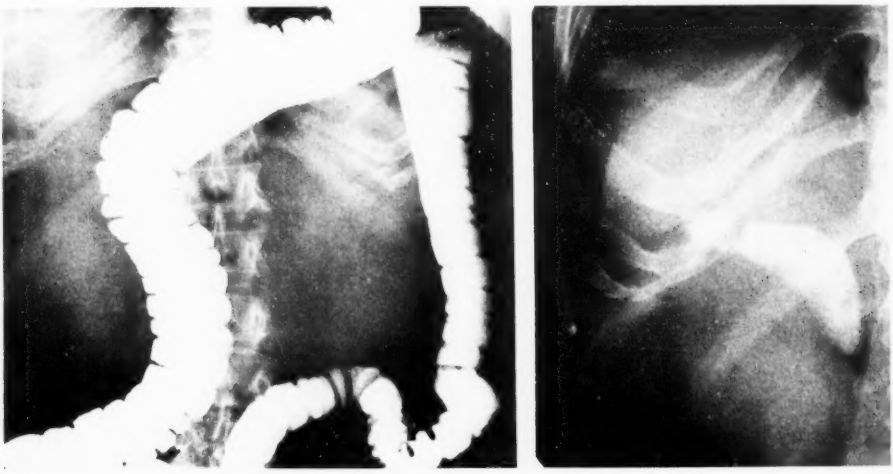
"Microscopic Description: Microscopic examination of a section through the wall of the cyst reveals some relatively normal-looking hepatic tissue, which in the outer layers next to the cyst wall is somewhat atrophic. The wall of the cyst for the most part consists of compact layers of fibrous tissue. A lining layer is difficult to demonstrate, although it is entirely possible because of the size and duration of the cyst that the epithelial lining has been destroyed through pressure atrophy.

Diagnosis: Congenital cyst of the liver."

This patient is at present well and shows no recurrence of the cyst.

Case 2.—A 50-year-old white married woman was admitted to Misericordia Hospital on May 15, 1953. Approximately four months prior to her admission, she noticed a lump in her abdomen in the upper right side. It was not tender, and it moved about when she touched it. It increased in size, and she later developed some pain in her chest for which she consulted her physician. Her present

Fig. 2.—Photograph of x-rays showing visceral displacement of colon on the left and gall bladder on the right.



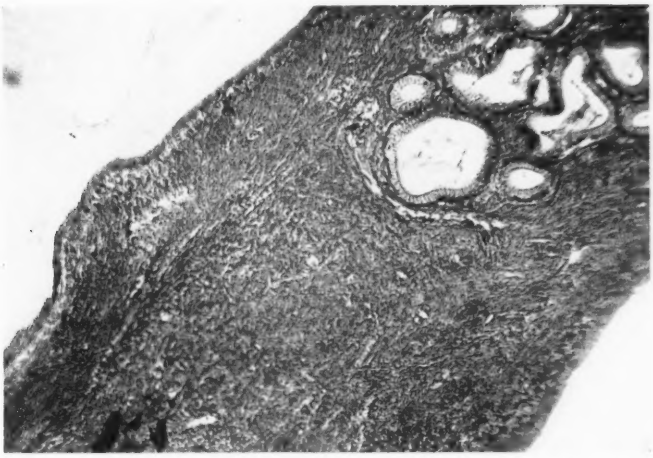


Fig. 3.—Photomicrograph of cyst wall; bile ducts are well shown in the upper right corner of photograph.

history was otherwise entirely negative. Past medical history revealed that she had had an abdominal hysterectomy 14 years previously, with an incidental appendectomy. Family history revealed a history of diabetes mellitus in her father and one brother. Her social history was irrelevant. The only abnormal physical findings were the presence of a cystocele and an abdominal mass. The latter was about the size of a grapefruit, firm, not tender, and located in the right upper abdomen just below the costal margin. It was freely movable, but motion did not cause pain. There was no pulsation in the mass. Temperature, pulse rate, respirations, and blood pressure were normal.

Laboratory findings were not significant, Urinalysis showed a trace of albumin but was negative otherwise. Complete blood cell count and determinations of blood urea nitrogen, sugar, and serum bilirubin were normal. Cephalin flocculation and sulfabromophthalein (Bromsulphalein) liver-function tests were normal. Blood Wassermann test was negative. Cholecystography revealed a normally functioning gall bladder, with the shadow displaced moderately to the left and upward. Gastrointestinal x-ray study was negative except for the following findings. The descending loop of the duodenum was displaced to the left, and the ascending colon and hepatic flexure of the colon were displaced markedly to the midline and downward. Intravenous urography showed a distortion of upper calix of the right kidney, suggesting a small cyst. On all x-ray studies, there was an oval large soft-tissue shadow present in the right upper abdomen. The roentgenologist stated that he believed that this soft-tissue mass originated in the liver.

The patient was operated upon on May 22, 1953. Exploration revealed a large cyst which originated from the undersurface of the right lobe of the liver and extended downward for a distance of 20 cm. The cyst was about 15 cm. wide and extended into the substance of the right lobe of the liver for a distance of 4 cm. in depth and 6 cm. in width. It pushed the ascending colon and transverse colon downward and to the left and the gall bladder upward and to the left. The cyst wall was thickened, fibrous, and well-encapsulated. It contained greenish-yellow fluid. The cyst was excised intact, the major vessels were clamped and ligated, and oozing was controlled with absorbable gelatin sponge and sutures. The edges of the liver were then sutured together over several pieces of absorbable gelatin sponge. A small Penrose drain was inserted into the subhepatic space, and the abdomen was closed. Her recovery was entirely uneventful, and her incision healed by primary union. The pathologic report was as follows:

"Gross Description: An irregular, multilocular cystic mass measuring 19×10 cms. The loculi contain a mucoid fluid which is golden-brown and contains cholesterol crystals. The loculi vary in size from 1 to 10 cm. The tissue content is 1232 cc.

"Microscopic Description: Sections of the liver cyst show it to be multilocular. Sections of the smaller cysts show an intact lining which is tall columnar epithelium with basal nuclei, resembling bile-duct epithelium. In the adjacent tissue there are relatively small regular-appearing biliary ducts. The stroma between these cysts is a rather loose edematous connective tissue. This fits the picture of a congenital cyst of the liver, in that it has peripheral bile ducts.

Author	Date	Patient: Age, Yr.	Patient: Sex	Gross Findings	Treatment	Result
Michel [85]	1856	60	M	Concave surface of the liver; cyst size of child's head	None	Autopsy finding
Gloz [51]	1864	28	M	Cyst lower anterior surface of left lobe of liver; 15,200 cc. of fluid removed by puncture	Aspiration	Death after third aspiration; autopsy finding
Cousins [35]	1874	27	F	Cyst in free border of liver; 2½ gal. fluid	Partial excision and marsupialization	Death; autopsy confirmed diagnosis
Drake [40]	1882	15	M	Cyst of right lobe of liver	Abdominal paracentesis	Death; autopsy gave correct diagnosis
Sharkey [113]	1882	11 mo.	M	Small cyst, center of liver, size of hazelnut	None	Autopsy finding
	1882	38	F	Right lobe—size of head of newborn child; straw-colored fluid, fibrous wall	None	Autopsy finding
Atkinson [10]	1885	32	F	Tense thin-walled cyst at quadrate lobe of liver	Abdominal section and aspiration of cyst	Recovery
Winckler [136]	1891	38	F	Cyst lower surface of the liver, 8 L.	Aspiration and drainage	Recovery
Bagot [11]	1892	Fetus	F	Left lobe connected into cyst, 48 oz. fluid; dystocia caused by it	None	Autopsy finding
Robson [108]	1892	42	F	Cyst within liver, 6 oz.	Aspirated	Operation; recovery; died 3 wk. later
Bayer [12]	1892	56	F	Cyst right lobe, 8 L. of fluid	Aspiration and drainage	Recovery—temporary, fistula
Keen [66]	1892	34	F	Cyst adenoma of bile ducts	Enucleation, drainage	Recovery, well 6 yr. later
Whitton [134]	1892	47	F	Undersurface of the liver, unilocular cyst, 8 oz.	Laparotomy; aspiration later	Recovery
Müller [91]	1893	59	F	Large cyst lower surface of the liver, 6 L., chocolate-colored fluid	Marsupialized, partial excision	Recovery
Zahn [137]	1896	38	M	Cyst right lobe, size of a walnut	None	Autopsy finding
		48	F	Cyst right lobe, size of bean	None	Autopsy finding
		53	F	Cyst left lobe, size of hazelnut	None	Autopsy finding
		50	M	Cyst right lobe, size of cherry	None	Autopsy finding
		42	M	Cyst right lobe, 30×9×6 mm.	None	Autopsy finding
		73	M	Cyst right lobe, 21×13 mm.	None	Autopsy finding
		57	F	Cyst right lobe, 13×7 mm.	None	Autopsy finding
		58	F	Cyst anterior right lobe, 2×4×2 mm.	None	Autopsy finding
		57	F	Cyst right lobe, 12×10 mm.	None	Autopsy finding
		55	M	Cyst anterior surface left lobe, 24×8 mm.	None	Autopsy finding
		60	M	Cyst anterior surface liver, 11×15 mm.	None	Autopsy finding
Chrobak [27]	1898	46	F	Cyst right lobe, 0.5 L. greenish-yellow fluid	Two-stage operation; incision and drainage	Recovery
Bobrow [17]	1899	51	Not given	Cyst just above gall bladder	Cavity packed with iodoform gauze	Not stated
Leppmann [69]	1900	14	F	Lower surface of the liver, 1,500 cc., size of child's head	Punctured, drained, marsupialized; cyst removed few days later	Recovery, but fistula persisted
M'Donnell [82]	1900	53	M	Mid-upper surface of the liver, 9.5 cm. in diameter	None	Autopsy finding
Porter [105]	1900	63	F	Large cyst, more than a gallon of fluid	Drained	Patient recovered
Hofmann [61]	1902	28	F	Cyst in quadrate lobe, 16 cm. ×10.3 cm.; fluid yellowish, like bile; no parasites found	Excision of cyst	Recovery
Morton [89]	1903	63	F	Cyst in quadrate lobe, size of an orange	Drainage	Recovery
Belaustegui*	1904	19	F	Cyst of liver, 800 cc. fluid	Marsupialization	Not stated
Doran [39]	1904	42	F	Cyst of whole quadrate and left lobe, 40 oz. fluid	Drainage of cyst	Recovery; well 7 mo. later
Bland-Sutton [16]	1905	75	F	Lower border of left lobe, 2 pt. brownish fluid	Excision	Uneventful recovery
		38	F	Cyst of liver—free border	None	Autopsy finding
Ikonnikoff [62]	1906	44	F	Cyst of right lobe of liver	Partial excision, marsupialization	Recovery
Sharp [114]	1906	7	M	Left lobe, larger than a man's head, 3 qt. fluid	Partial resection and drainage	Recovery

Author	Date	Patient		Gross Findings	Treatment	Result
		Age, Yr.	Sex			
Gourdet [52]	1909	Middle age	F	Inferior face middle lobe	Marsupialized	Patient died 3 days later
v. Haberer [55]	1909	34	F	Whole left lobe, size of child's head	Left lobe resected, closed with drainage	Recovery
Shaw & Elting [115]	1909	17 mo.	F	Lower right lobe of liver, 10 cm. cyst, 900 cc. clear yellow fluid, fibrous cyst wall	Exploration, aspiration, and drainage	Died of shock 2 hr. after operation
Plenk [104]	1910	40	F	Cyst of right lobe, 11 cc. fluid	None	Autopsy finding
Aldous [3]	1911	43	F	Solitary cyst in free border of liver, 1½ gal. dark fluid	Exploration and drainage	Not stated
Brown [21]	1912	68	M	Cyst size of orange in left quadrate lobe, bile-stained fluid, no parasites	None	Autopsy finding
Corner [31]	1912	Middle age	F	Cyst of right lobe, 4 in. in diameter	Excision of cyst	Recovery
Cotton & Burgess [33]	1912	60	F	Cyst—left lobe of liver	Aspirated and drained	Recovery
Green [53]	1912	59	F	Undersurface of right lobe, 7×11×11 cm., attached cyst 4×5×6 cm. (with cyst)	Cyst shelled out; cavity packed	Recovery
Munk [92]	1912	49	F	Left lobe, size of child's head	Two-stage operation; aspiration	Recovery
Reynolds [107]	1912	50	F	Lower border of left lobe, 2 pt. fluid	Cyst wall was dissected out; drained	Recovery
Tuffier [124]	1912	23	M	Whole lower border right lobe, size of nut to orange	Drained	Recovery
Boyd [19]	1913	27	F	Cyst of right lobe, 4 pt. fluid	Aspiration and drainage of cyst	Died 3 mo. later following rupture of sinus
Norris [94]	1913	51	F	Cyst size of orange, left lobe, 200 cc. fluid	Marsupialization	Recovery
Pilcher [103]	1913	70	M	Cyst of right lobe, 2 qt. amber fluid	Partial excision and marsupialization; excision with drainage	Recovery
Sonntag [118]	1913	25	F	Cyst right lobe, size of child's head	Excision with drainage	Recovery
Borden [18]	1914	50	F	Cyst between diaphragm and top of liver, 3,600 cc. fluid	Aspiration of largest cyst	Recovery
Dujarrier [41]	1914	34	F	Inferior edge right lobe, 9×5×5 cm.	Excised, incision closed without drain	Recovery
Everidge [46]	1914	16	F	Cyst between gall bladder and longitudinal fissure, 56 oz. fluid	Aspirated	Recovery
Grigorjew [54]	1914	56	F	Cyst size of child's head	Excision	Recovery, with fistula
Parin [98]	1914	22	M	Cyst left lobe, 1,900-2,600 cc. fluid	Excised	Patient collapsed after operation
Urrutia [125]	1916	8	M	Cyst deep in liver, 200 gm. fluid	Marsupialization	Died few hours later
Bevan [14]	1919	50	F	Right and left lobes just below round ligaments	Evacuation of cyst	Recovery
Soto [119]	1919	46	F	Attached by pedicle to inferior face of liver, 1,800 gm. fluid	Marsupialized	Recovery with fistula for 3 mo.
Evans [45]	1921	53	F	Large cyst under surface, 6×6×6 mm. surrounded by smaller cysts	Partial excision; drainage	Recovery; persistent sinus
Allman [8]	1922	Not given	F	Cyst of right lobe, 600 cc. clear fluid, no ova or parasites	Partial excision	Recovery
Margarucci [78]	1922	67	F	Cyst right lobe, 8 L. fluid	Excision	Recovery
Allende [6]	1923	56	F	Anterior face of right lobe, size of child's head, 2,200 cc. fluid	Aspirated, marsupialization	Not stated
Costantini & Duboucher [32]	1923	40	F	Anterior inferior surface of right lobe, size of child's head	Aspirated	Death 5th day after operation
Jones [64]	1923	18	F	Cyst, left lobe—9×10 cm., 900 cc. excision fluid	Excision	Recovery
Schaack [112]	1923	29	F	Cyst, left lobe, 5 L. fluid	Drainage	Recovery
Vila [127]	1923	46	F	Cyst left lobe and quadrate lobe; one contained 2.5 L. of yellow-green fluid	Excision of one, drainage of other	Not stated
Keller [65]	1924	48	F	Right lobe of liver, size of man's head, 3 to 4 L. fluid	Punctured; marsupialization	Recovery
Maes	1924	42	F	Cyst right lobe, 8 L. fluid	Marsupialization	Recovery
		34	Not stated	Cyst right lobe, size of a thumb	Excision	Recovery
Scalone [111]	1924	8	F	Cyst, 10 L. of fluid	Marsupialization	Recovery

Cases of Solitary Nonparasitic Cyst of the Liver—Continued.

Author	Date	Patient: Age, Yr.	Patient: Sex	Gross Findings	Treatment	Result
Alexander [5]	1925	11	M	Multilocular cyst, right lobe, fluid contained cholesterin crystals	Excision and drainage	Death from collapse 2 hr. after operation
Gutiérrez †	1926	67	F	Cyst of right lobe, 5 L. of lemon-colored fluid	Marsupialization	Recovery
Harrington [56]	1926	54	F	Cyst of right and left lobes, 12×10×8 cm., multilocular and hemorrhagic	Excision	Recovery
Danna ‡	1927	Not stated	M	Cyst of liver	Twice drained; cyst wall extruded after second drainage	Recovery; liver normal at later operation
McGlannan [84]	1927	30	F	Cyst of lower surface, 9×2 in., 24 oz. fluid	Drainage of cyst	Recovery
Orr & Thurston [97]	1927	26	M	Strangulated cyst, left lobe, 15 cm. in diameter	Excision	Recovery
Faltin [48]	1928	44	F	Cyst, right lobe, 1 L. fluid	Excision	Recovery
Moll [86]	1928	Fetus	Not stated	Cyst of entire right lobe containing 110 cc. of yellowish fluid	None	Autopsy finding
Zeno	1928	39	F	Cyst, inferior surface of liver, containing 4 L. of bottle-green fluid	Partial excision and marsupialization	Recovery
Althabe & Muiños §	1929	64	M	Three solitary cysts in right lobe, 8 L. in largest	Two small cysts excised; large cyst marsupialized	Recovery
Caylor [25]	1929	..	..	24 cases reported but unable to identify cases individually; 4 cases polycystic disease, leaving 20 cases of solitary cyst		
Stoesser & Wangensteen [122]	1929	10 mo.	M	Cyst, 1.5 L. fluid	Partial excision and marsupialization	Recovery
	1929	59	F	Cyst lower edge of liver, just left of gall bladder, size of orange	Excision	Recovery
Vila & Etcheverry [128]	1930	45	F	Cyst on liver, size of pigeon's egg	Excised; packed with gauze	Not stated
Zeno [138]	1930	33	F	Cyst containing 600 cc. fluid on inferior surface of right lobe of liver	Excision	Recovery; well 15 yr. later
Muto & Hanzawa [93]	1930	56	F	Cyst, size of child's head, left lobe	Excision	Recovery
Toland [123]	1930	43	F	14½ lb. cyst, pedunculated, anterior surface liver	Marsupialization	Recovery
	1930	58	F	10 cm. pedunculated cyst, left lobe liver	Excision	Recovery
Ackman & Rhea [2]	1931	61	F	Right lobe, multilocular cyst, 16 cm.	Marsupialization	Recovery
Hermann & Griffin [60]	1931	32	F	Cyst in region of porta hepatis, multilocular	Incision and drainage	Recovery
Picard [102]	1931	61	F	Cyst, right lobe liver	Excision	Recovery
Wakeley & MacMyn [130]	1931	40	M	Cyst left lobe of liver, size of large orange, 12 oz. fluid	Enucleated	Recovery; well 10 yr. later
	1931	51	F	Cyst left lobe, 80 cc. fluid	Excision	Recovery
Beattie & Robertson [13]	1932	35	F	Cyst of surface of liver, 20 oz. fluid	Excision	Recovery
Knoflach [67]	1932	32	F	Cyst right lobe, size of child's head	Marsupialization	Recovery
Parry [99]	1932	26	F	Cyst completely filling abdomen arising from lower edge of left lobe by broad thick pedicle, 5 L. fluid	Excision	Recovery
Sandberg [110]	1933	48	F	Multilocular cyst right lobe, 25×15 cm., 1,100 gm. fluid	Excision	Recovery
Carling [24]	1934	28	F	Cyst right lobe, 2½ pt. fluid	Drainage and anastomosis to gall bladder	Recovery
Eliason [42]	1934	3 9 mo.	F	Cyst undersurface between 2 lobes, 9 cm., 450 cc. fluid	Excision	Recovery
Masciottra & Etcheverry ‖	1934	30	F	Cyst anterior superior surface right lobe, 300 cc. fluid	Aspirated and drained	Not stated
Lenormant & Calvet [68]	1935	46	F	Cyst left lobe liver, 1,500 cc. fluid	Marsupialization	Recovery
Vander Veer [126]	1935	28	F	Cyst between right and middle lobes of the liver, 19×16×18 cm.	Excised	Recovery
Atakam [9]	1936	9	F	Cyst left lobe, 21×18 cm., 500 cc. fluid	Excision	Recovery
Fabre & Gadrat [47]	1936	52	F	Cyst, size of fetal head, on inferior left lobe	Excision	Recovery
	1936	64	M	Cyst, size of fetus, in left lobe	Excision	Recovery
Mallet-Guy & Aufrère [76]	1936	47	F	Cyst size of an orange in quadrate lobe	Excision	Recovery

Cases of Solitary Nonparasitic Cyst of the Liver—Continued.

Author	Date	Patient		Gross Findings	Treatment	Result
		Age, Yr.	Sex			
Quénu [100]	1936	45	F	Large multilocular cyst, 11 L.	Aspirated, marsupialized	Recovery; well 10 mo. later
Warthen & Griffin [132]	1936	38	F	Cyst right lobe, 29×20 cm., 4,950 cc. fluid	Excision	Recovery
White [133]	1936	4 mo.	M	Cyst right lobe liver	Excision	Recovery
Wikle & Charache [135]	1936	7	M	Cyst right lobe liver filling abdominal cavity, 3.2 L. fluid	Excision	Recovery
C. R. Davis [37]	1937	67	F	Perforated cyst of liver	Excision	Recovery; well 2½ yr. later
Attix ¶	1938	49	F	Cyst containing 1,000 cc. turbid viscid fluid	Excision	Recovery
Bartlett ‡	1938	53	F	Cyst, size of small grapefruit, anterior inferior surface right lobe	Excision	Recovery
Ochsner [90]	1938	56	F	Cyst of under surface of right lobe of liver, 3½ gal. fluid	Partial excision and marsupialization	Recovery; liver normal at laparotomy 1 yr. later
B. F. Davis [38]	1939	50	F	Large cyst containing 3,300 cc. fluid; location in liver not given	Partial excision with drainage; later sclerosing agents	Recovery
Jennings [63]	1939	50	F	Large cyst containing 3,300 cc. fluid; location in liver not given	Excision	Recovery
Patry [100]	1939	76	F	Pedicled cyst of liver containing liter of fluid	Excision	Recovery
Maingot [75]	1940	49	F	Cyst right lobe, 3 pt. fluid	Aspiration and drainage	Recovery; well 9 mo. later
Montgomery [88]	1940	6	F	Cyst of liver near round ligament 8×7 cm.	Excision	Recovery
	1940	6 mo.	F	Large cyst liver, 1.5 L. fluid	Partial excision and marsupialization	Recovery
Sapinski [109]	1941	32	F	Cyst, size of child's head, on underside liver	Drainage	Recovery
Bisgaard-Frantzen [15]	1942	32	F	Large multilocular cyst, 2,700 cc. fluid	Aspiration; later excision	Recovery
Jorge [64]	1942	52	F	Cyst in left lobe containing 1,000 cc. fluid	Drainage	Recovery
Masciottra [79]	1942	72	F	Cyst of right lobe containing 600 cc. fluid	Partial excision and drainage	Recovery
Munroe [87]	1942	9 mo.	M	Cyst right lobe completely filled upper right and part of lower abdomen	Marsupialized	Recovery
Alessandrini & Labatut [1]	1943	28	F	Large cyst; location in liver not stated	Aspiration and suture	Recovery
	1943	38	F	Cyst of interior surface of liver, 1,200 cc. fluid	Marsupialization	Recovery
Cunningham [36]	1943	62	F	Cyst inferior margin right lobe	Excision	Not stated
Galindez [50]	1943	42	F	Large intrahepatic cyst, 12 L. serous bile-stained fluid	Marsupialization	Recovery
Gutiérrez ††	1943	67	F	Cyst size of cocoanut and second (larger), both in left lobe	Smaller excised; larger marsupialized	Not stated
McCaughan & Rassieur	1943	82	F	Cyst right lobe, 7.5×7.5×5 cm., 180 cc. fluid	Incision and drainage	Recovery
	1943	60	F	Cyst right lobe, 400 to 500 cc. fluid	Aspiration	Recovery
Eliason & Smith [43]	1944	2½	M	Cyst right lobe, 10×14×18 cm., clear yellow fluid	Excision	Recovery; well 16 mo. later
	1944	12	F	Large cyst; location in liver not stated	Marsupialization	Recovery
Helweg-Larsen [58]	1944	25	F	Cyst containing 1.3 L. fluid	Drainage	Recovery; persistent fistula
	1944	38	F	Cyst containing 3 L. fluid	Excision	Recovery
Gonzalez ‡‡	1945	58	F	Cyst on inferior surface of liver containing 1 L. of fluid	Marsupialization	Not stated
	1945	67	F	Multiloculated cyst of liver	Marsupialization	Recovery
Zeno	1945	56	F	Cyst of liver below falciform ligament containing 3 L.	Partial excision and drainage	Not stated
Villaca [129]	1945	38	F	Cyst of superior surface of liver	Partial excision and marsupialization	Recovery
	1945	55	M	Small cyst on superior anterior surface of liver	Excision	Recovery
	1945	12	M	Cyst inferior surface right and left lobes, 300 cc. fluid	Partial resection and marsupialization	Recovery

Cases of Solitary Nonparasitic Cyst of the Liver—Continued.

Author	Date	Patient		Gross Findings	Treatment	Result
		Age, Yr.	Sex			
Courty & Foiret [34]	1946	47	F	Cyst, size of head of fetus, in quadrate lobe of liver	Excision	Recovery
Flamini [49]	1946	30	F	Cyst right lobe, size of goose egg	Excision	Recovery
Longo [71]	1947	2	M	Cyst right lobe, 350 cc. fluid	Partial resection and marsupialization	Recovery
Chaffin [26]	1948	11	M	Cyst of left lobe of liver containing 2 qt. of fluid	Marsupialization	Recovery
Hedin [57]	1948	57	F	Cyst 18×12×14 cm. in left lobe of liver	Excision	Not stated
Lulenski [73]	1948	42	F	Cyst left lobe, 4×4×6 in., ruptured	Aspiration and resection	Recovery
Spriet & Yuen [120]	1948	63	F	Cyst twice the size of a fetal head continuous with Glisson's capsule	Partial excision	Recovery
Clarke & Latimer [30]	1949	40	F	Cyst right lobe, 15 cm., weighed 253 gm.	Excision	Recovery
Caravati [23]	1950	33	M	Cyst, almost covering entire right lobe of the liver, 3,300 cc. of liquid	Aspirated; marsupialized	Recovery; well 7 mo. later
J. Espionosa & E. Espionosa [44]	1950	50	F	Cyst, lower face of the liver, 7 L.; cyst superior surface right lobe, 250 cc.	Marsupialization; drainage	Recovery
Pevaroff [101]	1950	51	F	Cyst in anterior inferior portion of right lobe of liver, 7.5 cm. in diameter	Excision	Recovery
Matronola [80]	1951	16	F	Cyst of liver containing 1,600 cc. bile-colored fluid	Partial resection and anastomosis to duodenum	Recovery
Shields [116]	1951	61	M	Cyst in posteroinferior portion of the right lobe, 3,000 cc. clear fluid	First operation drained; second operation partial excision and drainage	Recovery
Stock	1951-1952	53	F	Cyst right lobe, large	Enucleated	Recovery
	1952	54	F	Cyst right lobe, 50 oz. fluid	Partial excision and drainage	Recovery
	1951-1952	65	F	Cyst, size of full-term pregnancy, attached with wide base	Excision attempted	Death from hemorrhage
	1951	55	M	Cyst on undersurface of liver, 3 cm.	Excision	Recovery
Abolfathi [1]	1952	77	F	Cyst of right lobe of liver, size of a large melon	Excision	Recovery
Burch & Jones [22]	1952	54	F	Huge cyst right and left lobes, 17,000 cc. fluid	Excision	Recovery; well 7 mo. later
Manheimer [77]	1953	71	M	Cysts of right lobe of liver, 2 smooth and 1 puckered; cyst on upper surface right lobe	Cyst anastomosed to stomach	Recovery
Warren & Pararo [131]	1953	27	F	Numerous thick-walled cysts	Excision	Recovery
		32	F	Multilocular cyst, 8 L.; location not given	Excised	Recovery
Cinelli [28]	1954	50	F	Cyst on anterior part of convex surface of liver; 4 L. greenish fluid	Portion excised, cavity marsupialized; cyst reevacuated 15 mo. later	Recovery
Horton [140]	1954	44	F	Cyst, right lobe, ruptured	Cyst evacuated and plugged with omentum; excised at second operation	Recovery
Long [70]	1954	55	F	Bulging from right lobe of liver, 18×14×12 cm.	Partial excision; marsupialization	Recovery
Geist	1954	44	F	Right lobe, 350 cc., 9 cm. diameter	Excision	Recovery
	1954	50	F	Undersurface of right lobe, 1,232 cc., 19×10 cm.	Excision	Recovery

* Belaustegui, E., cited by Allende.[7]
† Gutiérrez, A., cited by Allende.[7]
‡ Danna, J. A., in discussion on McGlannan.[84]
§ Althabe, B., and Muiños, A., cited by Allende.[7]
‖ Masciottra, R. L., and Etcheverry, M. A., cited by Allende.[7]
¶ Attix, F. F., in discussion on McCaughan.[81]
# Bartlett, R. W., in discussion on McCaughan.[81]
** Jorge, J. M., cited by Allende.[7]
†† Gutiérrez, A., cited by Allende.[7]
‡‡González, J. C. L; Borla, J. C., and Bogetti, H., cited by Allende.[7]

"Diagnosis: Cyst of the liver. Papanicolaou stain was done for malignant cells, but none were found."

This patient is at present well and without recurrence.

In conclusion, the literature of solitary nonparasitic cyst of the liver has been completely reviewed. Two patients with this lesion treated by the author are added to the list of collected cases.

1930 chestnut St. (3).

Mrs. Virginia Beatty, Curator, Medical Literature Service, College of Physicians of Philadelphia, aided in reviewing the literature.

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The Hematuria of Abnormal Hemoglobin Diseases

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The property of the red blood cell to sickle is a manifestation of abnormal molecular arrangement of that cell's hemoglobin. This was established by Pauling and co-workers in 1949.[1] Since then, other abnormal hemoglobins have been discovered by electrophoretic methods.[2] The classification and nomenclature associated with sickle-cell disease has been standardized.[3] Urologically, a discussion of hematological techniques and research is not important, but, clinically, association of hematuria with abnormal hemoglobin disease warrants more careful study and understanding of nomenclature than has been given in past urologic literature.

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These facts have been established by electrophoretic methods:

1. Normal adult red blood cells contain normal hemoglobin designated as hemoglobin A.

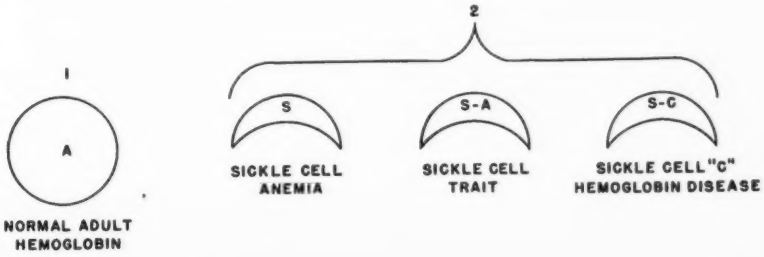
2. Red blood cells which sickle may contain (*a*) an abnormal hemoglobin designated hemoglobin S, (*b*) a combination of abnormal hemoglobin S and normal hemoglobin A, (*c*) a combination of abnormal hemoglobin S and another abnormal hemoglobin designated as hemoglobin C.

These facts may be correlated with established clinical nomenclature as follows (Figure):

Sickle-cell anemia = hemoglobin S
Sickle-cell trait = hemoglobins S and A
Sickle-cell hemoglobin C disease = hemoglobins S and C

To date all of these abnormal hemoglobins have been found in Negroes. These hemoglobin abnormalities are passed genetically according to Mendelian dominance.

The clinical features of sickle-cell anemia are well known: asthenic habitus, anemia, bone changes, jaundice, crisis, and splenomegaly. This report will deal only with sickle-cell trait and sickle-cell hemoglobin "C" disease, with particular reference to gross hematuria.



The previous urologic literature on this subject could not differentiate between these two distinct entities, sickle-cell hemoglobin C disease and trait, because no electrophoretic studies were available. Review of the cases previously reported in the literature shows that clinically some of them were probably sickle-cell hemoglobin C disease,* an entity that has not been brought to the urologists' attention. They were not properly identified and were erroneously called sickle-cell anemia or sickle-cell trait. In this paper we will correlate the hematologic and urologic findings, hoping to clarify the past urologic literature on this subject.

SICKLE-CELL TRAIT (HEMOGLOBINS S AND A)

Sickle-cell trait is characterized by presence of red cells which sickle, a paper electrophoresis graph showing hemoglobins S and A, normal body build, absence of bone changes, normal hemogram, no splenomegaly, and never a hematologic or bone crisis. Its interest to the urologist is that its cardinal symptom is hematuria.

Six such cases were collected, and the pertinent data are listed. All patients were originally admitted to the urologic service for gross hematuria.

Hematologic Data

1. *Anemia.*—None were anemic during or after the hematuria.

2. *Sickling of Red Cells.*—All had negative sickling tests on the direct dry peripheral smear, but all had positive sickling smears when the sodium metabisulfite test was used.

3. *Splenomegaly.*—None had splenomegaly or bone changes.

Urologic Data

1. *Hematuria.*—All were admitted because of gross hematuria.

2. *Duration and Course.*—The average time from the onset of the first episode of hematuria until sickle-cell trait disease was diagnosed as the cause of the bleeding was four years. The longest case was 10 years, and the shortest, only 3 weeks. Of these six cases, three patients bled several times but the other three have had innumerable episodes of gross hematuria.

3. *Pain.*—None had pain with hematuria.

4. *Pyelograms.*—All but one had normal intravenous pyelograms. Filling defects compatible with clots in the pelvis were found in one case. However, all had normal retrograde pyelograms.

5. *Cystoscopy.*—Lateralized bleeding was found in three of these six patients. No other abnormalities were noted on cystoscopy.

6. *Bacteriology.*—All had negative smears and cultures for routine and acid-fast organisms.

7. *Surgery.*—Two of the six patients had surgery. One patient had a nephrectomy, done in August, 1949, by the Army (he subsequently bled from the solitary kidney). The other operation was a renal exploration, done at Hines VA Hospital. No abnormalities were found at surgery, and, fortunately, the kidney was spared.

SICKLE-CELL HEMOGLOBIN C DISEASE

Sickle-cell hemoglobin C disease is characterized by red cells which sickle, a paper electrophoresis pattern showing hemoglobins S and C, normal body build, and moderate anemia associated with mild constitutional symptoms but no crisis. Splenomegaly may be present. It resembles a mild case of true sickle-cell anemia, but the patients never get so sick. Its interest to the urologist is that it, too, may first be recognized because of associated gross hematuria. This entity has not been described in the past urologic literature. Three such cases have been collected, and all patients were admitted to the urologic service originally because of gross hematuria. The pertinent data are listed below.

Hematologic Data

1. *Anemia.*—One of the three patients had severe anemia with his hematuria and had multiple transfusions. Another had moderate anemia during the hemauria, but his blood cell count returned to 4,400,000 per cubic millimeter at the time of discharge. The third patient had no anemia. All three

* References 4 and 5.

patients showed significant target cells on peripheral smear.

2. *Sickling of Red Cells.*—All three cases showed no sickling on dry smear, but there was positive sickling with sodium metabisulfite reagent.

3. *Splenomegaly.*—Two of the three patients had splenomegaly.

Urologic Data

1. *Hematuria.*—All were admitted because of gross hematuria.

2. *Duration and Course.*—The average time from the onset of the first episode of hematuria until sickle-cell hemoglobin C disease was diagnosed as the cause of bleeding was 15 months.

3. *Pain.*—None had pain with hematuria, although one patient passed clots per urethra.

4. *Pyelograms.*—One of the three cases had intravenous and retrograde pyelograms compatible with clots in the renal pelvis.

5. *Cystoscopy.*—In all three cases bleeding occurred in only one kidney. No other abnormalities were noted on cystoscopy.

6. *Bacteriology.*—All had negative smears and cultures for routine and acid-fast organisms.

7. *Surgery.*—One patient had a nephrectomy for persistent, severe hemorrhage. Hematuria stopped after surgery but recurred once, a year later.

COMMENT AND CONCLUSIONS

From the previously listed data these conclusions are worth emphasizing:

Although urologists are not primarily interested in diagnosis and treatment of abnormal hemoglobin diseases, it will probably be the urologist who will first see these patients, since the most significant complaint of these persons is gross hematuria; therefore, we should have some understanding of these diseases.

It would pay us to think of the abnormal hemoglobin diseases earlier in our work-up of hematuria problems in Negroes, because the time from initial urologic investigation until a diagnosis was established was approximately two and one-half years in our series. Further, as has been pointed out in another paper awaiting publication,[6] of 22 cases of hematuria, cause unknown, in Negroes discharged from Hines Hospital, 8 have subsequently been diagnosed as sickle-cell trait or sickle-cell hemoglobin C disease.

The emphasis on "anemia" associated with this disease should be removed, as only one of nine cases had a significant anemia.

Since anemia is no great problem, nephrectomy is contraindicated. Bleeding will always stop. Symptomatic and supportive treatment is indicated. Other workers are of the same opinion.[7] Two cases that had nephrectomy subsequently bled from the remaining kidney. Nephrectomy does not remove the basic cause—abnormal circulating hemoglobin.

It is worthless to examine a dry blood smear. None of nine cases showed sickling with this type of preparation.[6] Sickling will always be demonstrated with sodium metabisulfite, a strong reducing agent.

In a given case of hematuria under study, if other causes of splenomegaly have been ruled out, sickle-cell hemoglobin C disease should be considered if the spleen is palpable.

Since this a systemic disease, one would expect both kidneys to react the same way. Of nine cases, six were found to have lateralized bleeding. The explanation for this we cannot offer. Since cells will sickle with decreased oxygen tension, is it possible that the bleeding kidney is suffering from decreased oxygenation? Perhaps a minimal ptosis of the kidney with transient kinking of the arterial supply could decrease the oxygen tension sufficiently to cause sickling of cells in smaller blood vessels, with resultant thrombosis and infarction. Or could the kidney be the apparent focus of pathology because it contains so many small end-arteries which predispose to local oxygen deficit? The retina, which is essentially all end-arterioles, also suffers from the stigmata of abnormal hemoglobin disease.[8] Here, hemorrhages, too, are present and result in retinitis proliferans.

No diagnostic x-ray findings have been observed. Two cases showed pyelograms with probable clots in the pelvis.

SUMMARY

The hematuria of abnormal hemoglobin disease is discussed. Nine cases are summarized. Six belong to the sickle-cell trait (hemoglobins S and A) group, and three, to the sickle-cell hemoglobin C disease group. This latter group has not previously been identified in the surgical literature. All of the cases had complete hematologic work-up, including paper electrophoresis. The urologic findings are correlated with the hematologic data.

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Fatal Pancreatic Necrosis Following Choledochotomy and Cholangiography

Report of a Case

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and
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Acute pancreatic necrosis is an uncommon but dreaded complication of surgery in the epigastric region. Those discussing its etiology agree only that the cause usually is a combination of factors. Experimentally, acute pancreatic necrosis may result from obstruction of the pancreatic ducts in the presence of a secreting or stimulated gland.* Nutritional factors may be important.† Although pancreatic necrosis in animals can be produced by the retrograde injection of bile along the pancreatic duct, it cannot be produced in this way experimentally unless the physiologic limit of biliary pressure (375 mm. bile) is exceeded.‡ In such cases, rupture of the smaller pancreatic ducts occurs and results in the release of pancreatic enzymes into the intercellular spaces.§ Rich and Duff,[3] by injecting 3 to 10 cc. of India ink, showed that even small pressure excesses produced rupture of the smaller pancreatic ducts and extrusion of carbon particles into pancreatic tissue.

Recently, a patient of ours had the misfortune to develop fatal pancreatic necrosis after an elective operation for cholelithiasis. The catastrophic nature of this complication and the ever-present controversy concerning its etiology have prompted us to report this case.

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* References 1, 2, 3, and 4.

† References 2 and 5.

‡ References 3 and 6.

§ References 1 and 7.

REPORT OF CASE

A 39-year-old salesman was admitted to the Veterans Administration Hospital, Seattle, on March 30, 1954, with a three-week history of postprandial nausea, vomiting, and right upper quadrant colicky pain radiating to the right scapula. These symptoms developed suddenly three hours after a heavy meal. He had shaking chills and noted passage of light stools and dark urine. Four days later he entered another hospital, where his symptoms promptly subsided. A cholecystogram did not permit visualization of the gall bladder.

Ten days later, after having experienced several less severe recurrences of similar pain at home, he was admitted to the medical service of this hospital. His past history was significant in that in the previous seven or eight years he had had frequent episodes of "heartburn" coming on about one-half hour after eating fatty foods. In 1935 he had an appendectomy with an uncomplicated convalescence. In 1946 he was hospitalized for right flank pain diagnosed as due to a ureteral stone. The stone was not recovered.

Physical Examination. — Physical examination revealed an obese but otherwise healthy-appearing 39-year-old man. The temperature was 98 F; pulse rate, 76, and blood pressure, 105/60. Positive physical findings were limited to the abdomen, which was rotund and soft, and no spasm or palpable masses were present. There was tenderness on inspiration, with the palpating hand deep in the right upper quadrant. There was no rebound tenderness. Bowel tones were normal.

Preoperative Laboratory and X-Ray Findings.— WBC 10,200, with normal differential count; hematocrit, 44%; urinalysis, normal; alkaline phosphatase, 5.5 units; serum bilirubin, 7 mg. per 100 cc.; thymol turbidity, 1.8 cc.; cephalin flocculation, negative; serum amylase, 64 units (normal); prothrombin time, 100%. Chest x-ray, normal;

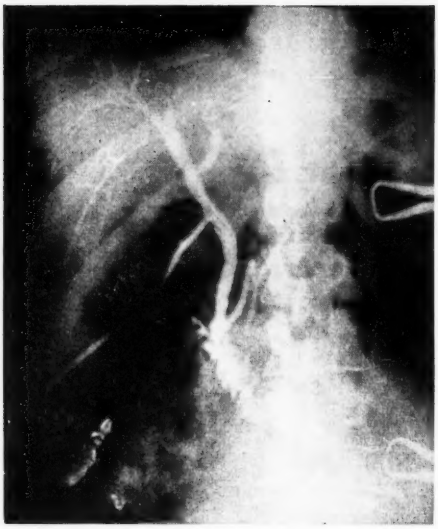

Fig. 1.—Cholangiogram shows reflux of dye to the tail of the duct of Wirsung and filling of accessory pancreatic duct.

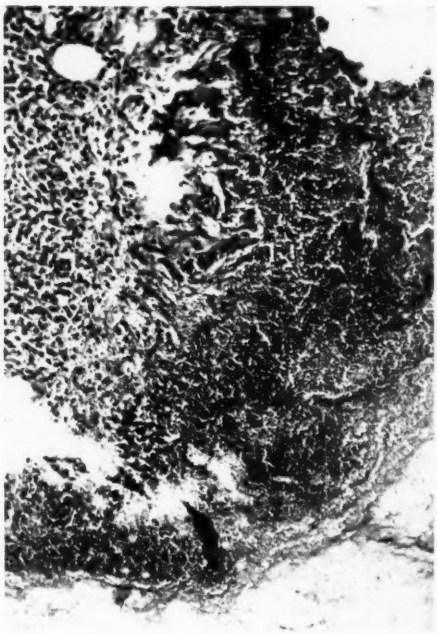

Fig. 3.—Photomicrograph of pancreas shows distorted pancreatic architecture in upper left, a zone of hemorrhagic necrosis, and a zone of fat necrosis at lower margin.

cholecystogram again showed no concentration of dye; G. I. series, normal; intravenous pyelogram, normal.

Course in Hospital.—After evaluation the patient was transferred to the surgical service for cholecystectomy. On April 12, 1954, with the patient under cyclopropane-ether anesthesia with thiopental (Pentothal) sodium induction, cholecystectomy, exploration of the common duct, and cholangiography were performed. The gall bladder was thick-walled and covered with old fibrous adhesions and contained multiple small irregular stones, the largest being 0.3 cm. in diameter. The common duct was increased in external diameter to approximately 1.5 cm. Upon opening it, however, the wall was found to be thickened and edematous, and the lumen was only 4 mm. Only the No. 3 Bakes dilator could

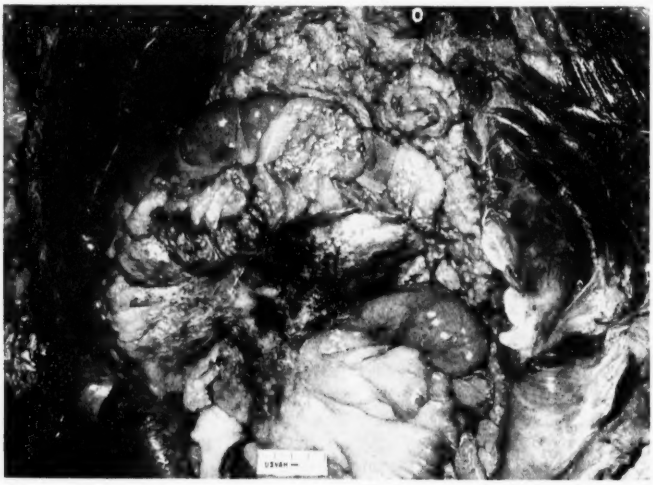

Fig. 2.—Photograph of pancreas *in situ* shows typical diffuse hemorrhage and fat necrosis.

pass into the duodenum. No stones were present in the common duct. After a No. 14 short-limbed T-tube was sutured in place, two cholangiograms were taken, with the use of 15 cc. of 35% iodopyracet (Diodrast) on each injection. On the second film the biliary system and the full length of the pancreatic duct were well demonstrated (Fig. 1). The procedure, which was technically difficult because of the patient's obesity, lasted 5 hours 15 minutes. However, the patient had stable vital signs throughout the operation and was returned to the recovery room apparently in good condition. Approximately 12 hours later he developed shock, diaphoresis, dyspnea,

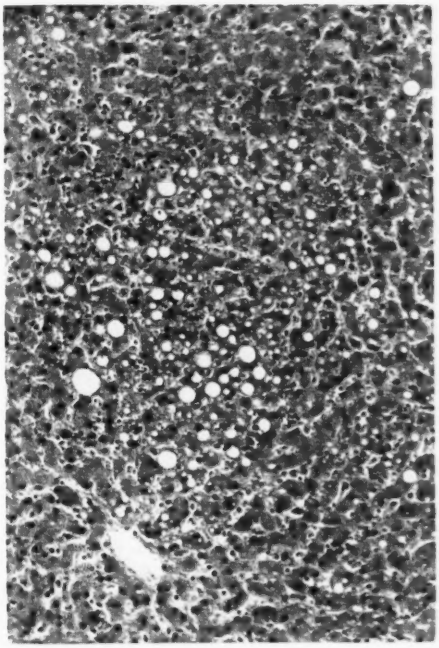

Fig. 4.—Photomicrograph of liver shows moderate fatty infiltration.

and a weak pulse of 160. After 1 unit of blood was given, the hematocrit reading was 50%. Examination revealed no evidence of atelectasis or hemorrhage. Serum amylase on the first postoperative day was more than 600 units; on the second postoperative day, 516 units; on the third postoperative day, 178 units. The diagnosis of acute pancreatitis was made. The patient was treated with atropine, gastric suction, antibiotics, and calcium gluconate. On the second postoperative day, the blood pressure fell to 70/0 and intravenous levarterenol (Levophed) bitartrate was administered for 24 hours. On the fourth day he developed bronchospasm, jaundice, and abdominal distention. He became apprehensive and hyperactive, requiring sedation. On the fifth postoperative day he appeared improved. Gastric suction was discontinued, and he was fed liquids. On the sixth postoperative day he began convulsing and, despite intravenous phenobarbital sodium, died 40 minutes later.

Autopsy.— Postmortem examination revealed acute pancreatic necrosis (Figs. 2 and 3), with extensive fat necrosis throughout the abdomen as well as the parietal pleura. The common duct and hepatic artery were intact. The pancreatic duct (duct of Wirsung) joined the common duct 1 cm. proximal to the papilla. The duct of Santorini communicated with the duct of Wirsung but did not have a separate opening into the duodenum. Hepatomegaly (2650 gm.) with moderate fatty infiltration of the liver was also present (Fig. 4).

COMMENT

Several possibilities have been considered in a search for the etiology of pancreatic necrosis in this man: (1) direct surgical trauma, (2) hypersensitivity to 35% iodopyracet, (3) reflux injection of bile and iodopyracet along the pancreatic duct, (4) excessive pressure and volume of iodopyracet in the presence of a moderately stenotic or spastic sphincter of Oddi, and (5) nutritional deficiency with a particular susceptibility to pancreatitis. Neither the length of operation, infarction, metaplasia of pancreatic ductal epithelium, nor the infection was thought to be primarily etiologic in this case. The first possibility, trauma to the pancreas, can be rejected as there was no manipulation of the pancreas. The second, hypersensitivity to iodopyracet, also does not appear likely as the patient had previously had an intravenous pyelogram with the use of sodium iodomethamate (Neo-Iopax, Schering) without reaction; possibilities 3 and 4 can be considered together. We believe that the reflux of a large amount of dye under excessive pressure is the primary cause of pancreatic necrosis in this man. A reflux of iodopyracet (and bile) to the tail of the pancreatic duct can be observed on the cholangiogram. Howell and Bergh [8] recorded the serum amylase level at intervals after cholangiography and found that, in 25 of 27 patients in whom pancreatic reflux occurred, the amylase increased to

more than 200 units, the amount of rise in the amylase paralleling the degree of pressure of injection in most instances. In our case, the iodopyracet was injected with a syringe and the pressure probably exceeded the secretory pressure of the liver (approximately 30 cm. H_2O.[8] The volume of 15 cc. which was injected twice is not considered excessive by many authors, although Swedberg [9] recommends 3 to 4 cc. of undiluted dye. Marizzi used 3 cc. of iodized oil (Lipiodol) in the first series of operative cholangiographies.

The moderate stenosis of the sphincter of Oddi (0.3 cm.) with possible additional postoperative spasm and edema, together with the absence of a separate opening for the duct of Santorini, could have permitted pathologic pressures within the pancreatic duct, even without the injection of iodopyracet, and certainly with it. It is of some interest that in 67 cholangiograms done in this hospital in three years some reflux of dye occurred in 33 cases. Only two of these, however, showed reflux to the tail of the pancreas.

The fifth etiologic possibility in this case is concerned with the relationship of methionine and protein nutrition to pancreatic protection. It has been shown that a low-protein, high-fat diet produces, in experimental animals, atrophic and fibrotic changes in the pancreas, in addition to fatty infiltration of the liver.[10] Malnutrition in young children in tropical zones results in a fatty liver and fibrotic changes in the pancreas.[11] Laennec's cirrhosis, often observed in alcoholics with protein-deficient diets, is commonly preceded by fatty infiltration of the liver.[12] The increased incidence of pancreatitis in alcoholics is recognized.[13] Investigators have demonstrated that ethionine (a presumed antagonist of methionine) will produce diffuse pancreatitis with focal necrosis as well as fatty infiltration of the liver in experimental animals, an effect which is blocked by the simultaneous administration of methionine.[5] The presence of fatty infiltration of the liver in our patient suggests a protein deficiency, although neither it nor a history of a high alcohol intake was elicited.

From the study of this case, we recommend that the volume of dye be kept small and that the injection pressure of iodopyracet be controlled to below 30 cm. H_2O using any simple gravitational technique. The presence of a stenotic or spastic sphincter of Oddi and possibly a fatty liver should alert one to the possibility of pathologic pressures within the biliary-pancreatic duct system. The custom of clamping the T-tube on the way from the operating room to the recovery room bears scrutiny.

SUMMARY

A case history of fatal pancreatic necrosis after choledochotomy and cholangiography is presented, with reference to some of the pertinent literature. The possible etiologic factors in this case are discussed. Our conclusion is that the complication in this case resulted from a combination of factors: (1) the reflux of bile and iodopyracet (Diodrast) under pressure along the pancreatic duct, (2) an anatomical arrangement of the pancreatic-biliary duct system which might have perpetuated this intraluminal pressure, and (3) the possibility that protein deficiency increased the patient's susceptibility to pancreatitis. This possibility is based on the postmortem finding of fatty infiltration of the liver, the established clinical correlation of pancreatitis to alcoholism, and recent experimental work with methionine and ethionine. Control of pressure and volume of dye in cholangiography is endorsed.

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Use of Braided Wire Seton for Two-Stage Anorectal Fistula Operation

Preliminary Report

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Fistulous tracts about the anus deep to the external sphincter muscle are often associated with such destruction in their vicinity that it is often not anatomically or functionally advisable to cut through the sphincter muscle at the time the fistula is first attacked. The advisability of completely cutting through a fistulous tract in a one-stage operation depends, of course, on the length or depth of the fistula, as well as upon the nature of the surrounding tissue. The unsupported ends of a cut sphincter may likely fall back into recesses of an abscess cavity behind it and even may be held apart permanently as the cavity fills in with new tissue around the sphincter. This may result in partial or total incontinence or a deep trough at the anal verge, which may be difficult to cleanse after a bowel movement. Hence, it may be expedient at times to isolate the sphincter muscle when first cutting through the fistulous tract. The attack upon the part of the fistula in direct contact with the sphincter is reserved, then, for a secondary operation after the cavity associated with the fistula and connecting abscess has filled in solidly enough against the sphincter. The latter thus maintains its shape and integrity when it is finally cut through. Even though the external sphincter may be repaired after an ill-advised one-stage operation, the internal sphincter is almost impossible to repair. Anal control is thus doubtful or precarious, since the internal sphincter closes the anus mechanically rather than by reflex action.

Pennington [1] in 1907 was one of the first to point out the advantage of considering a two-stage fistula operation in appropriate instances. Many others have followed this principle, among whom Allen and Haskell [2] in 1934 reported 266 cases of two-stage operations for anal or anorectal fistulae. They found definite advantages in awaiting for closure and drainage of infection after the first stage of a two-stage operation before finally cutting the sphincter muscles.

METHODS AND MATERIALS

In the first stage of a two-stage fistula operation a probe may be passed through the fistulous tract. The tissues between the skin and probe are cut through both anteriorly and posteriorly to the sphincter muscle, leaving the latter as a bridge across the cavity made by the incision. Some nonabsorbable material is then threaded into the eye of the probe and pulled with the probe through the remaining tract proximal to the sphincter. The thread is tied very loosely but securely as a seton around the sphincter, allowing its loop and ends to protrude while the cavity made by the attack upon the fistula and abscess is packed with gauze. The seton should be of some pliable material, so that the loose ends do not irritate the tissues of the patient. The first stage of the fistula correction is usually a hospital procedure. The second stage is the event of cutting through the remaining part of the fistulous tract which is bridged by the sphincter and should take place only when the sphinc-

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ter is firmly supported by the newly granulated surrounding tissues. The seton by this time is also buried, except for the long loop and ends, which should always be left protruding to the outside. Usually 20 to 50 days is required for solid filling of the tissues to the sphincter.

The material used as a seton and its method of application have varied with different operators.

Pennington [1] used a rubber band which the patient himself pulled from time to time. By this method the process of severance may be uncertain or take two to three weeks. For quicker action he employed a rubber band, which he attempted to hold taut by use of perforated shot at each end. These two methods were very painful.

Buie [3] used a strong thread about the sphincter in a slipknot fashion and then gradually tightened the knot. Success here is uncertain and painful.

Silk and cotton may fray or disrupt prematurely. Silkworm-gut is too stiff and its ends cause pain, and plain steel wire has the same disadvantages. Gorsch and Becker [4] tied knots in No. 40 steel wire to facilitate cutting through the musculature.

In my cases, which to date number five, a stainless braided No. 000 (Ethicon) steel wire is used as a seton. This wire is composed of many strands of very fine wire twisted into a soft braid, the cut ends of which are about as soft as heavy silk and do not prick the skin. The multiplicity and twisting of the wires actually produce a cutting edge when moved to and fro against a tissue. Its further advantage lies in the fact that it need not be applied as a compressing loop, but applied loosely it may be pulled to and fro against tissues with relatively little pain.

The second stage of a two-stage fistula operation is usually done as a hospital procedure with anesthesia of some sort but can often be completed as an office procedure by using No. 000 (Ethicon) seton, as described. At each visit of the patient to the office the sphincter may be sawed through a very little distance by simply grasping both ends of the loop of the seton with straight clamps and keeping these clamps gently taut while a to-and-fro sawing motion is made against the sphincter with the seton loop. This procedure is repeated at intervals, depending upon the tolerance of the patient and the discretion of the surgeon, until the tissues are finally cut through. A topical or local anesthetic may be used but is usually not necessary. The resultant wound is almost indiscernible, owing to the lack of disturbance to any of the adjacent tissues, and bleeding is at a minimum. A very long fistulous tract attacked in stages may ordinarily require several hospitalizations and anesthesias and is, of course, accompanied with the hazards of bleeding. The office procedure with the use of the braided wire may at least be attempted before hospitalization, if decided upon, and may indeed be successful to the comfort of the patient and satisfaction of the surgeon. Straight tracts are most amenable to this method. Although it is not offered as a real improvement to surgical attack, I have found function and healing to be satisfactory with the use of the braided wire seton.

A further application may be attempted if we can successfully pass a braided stainless steel wire seton through a very short chronic fistulous tract while the patient is on the office table. The procedure as described for the second stage of the two-stage fistula operation may be rewarded by the saving of time, inconvenience, and expense.

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Acute Cardiac Tamponade, a Complication of Sternal Marrow Aspiration

Report of a Case

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Since Arinkin [1] first used sternal marrow aspiration, in 1927, the incidence of serious complications from the procedure has been low. However, the operation is not innocuous. Thirteen deaths following sternal puncture have been reported in the world literature,* all of which have occurred in the past 11 years. When performed, autopsies on these cases showed acute cardiac tamponade to be the cause of death. Our search of the literature indicates that the present report of a case of acute cardiac tamponade from sternal marrow aspiration is the first reported case in which the diagnosis was made and in which the tamponade was successfully treated.

REPORT OF A CASE

A 24-year-old Negro man was admitted to the Roper Hospital on Sept. 27, 1951, with the chief complaints of vomiting and swelling of the legs for the previous two weeks.

The patient stated that approximately one year before admission he was not accepted for military service because of high blood pressure. He was called again for preinduction examination five months prior to admission, but he was rejected and told that he had "high blood pressure and kidney trouble." The only symptoms he had noted at that time were urinary frequency and nocturia. He experienced the onset of frequent dizzy spells and occasional headaches one month before admission. Nausea and vomiting appeared six days prior to examination, following a meal of pork and shrimp. He vomited everything that he ate for the next three days, but the vomitus was never bloody and diarrhea did not occur. At the same time, he noted that his face and hands would appear swollen in the morning and that later in the day his abdomen and his feet would swell. He did not complain of dyspnea.

The past history and a review of systems yielded no pertinent information except for the fact that he had gained 5 to 10 lbs. in weight in the past four months.

Physical examination on admission showed a muscular young Negro man in no distress, with an oral temperature of 98.6 F, a pulse rate of 80 per minute, and a respiratory rate of 20 per minute. The blood pressure in the arms was 212/124 and in the left leg 284/202. The fundi demonstrated copper-wire effect, with spasm and nicking of the vessels and small areas of hemorrhage. The mucous membranes were pale. Cardiac examination revealed the heart to be enlarged to the left with the point of maximum intensity in the sixth interspace at the anterior axillary line. There was a Grade 2 systolic murmur over the entire precordium, but it was best heard at the primary aortic area. The liver was palpable 1.5 cm. below the costal margin at the midclavicular line. A slight degree of pedal edema was noted, but otherwise the physical examination was normal.

Laboratory examination showed the hemoglobin level to be 6 gm. and the red blood cells to be 2,400,000. The white blood cells were 4900, with 71% neutrophiles, 22% lymphocytes, 5% monocytes, and 2% eosinophiles. Urinalysis showed a specific gravity of 1.011, 2+ albumin, 5 to 6 WBC, 8 RBC, and 1+ casts. The sedimentation rate was 35 mm. per hour (Wintrobe), and the volume of packed cells was only 17%. A phenolsulfonphthalein test determined that only 13% of the dye could be recovered in two hours. The highest urinary specific gravity obtained on a Fishberg concentration test was 1.012. A stool examination revealed no blood, ova, or parasites present. The blood urea nitrogen

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* References 2 to 10.

on admission was 126 mg. per 100 cc. and creatinin was 9.1 mg. per 100 cc. The total serum proteins were 5.56 gm. per 100 cc., of which the albumin fraction was 4.42 gm. and the globulin fraction was 1.14 gm. The venous pressure was recorded on admission as 192 mm. of saline and a circulation time was reported as 11 seconds (arm to tongue, dehydrochloric acid [Decholin]). The serum sodium was 308 mg. per 100 cc. and the serum potassium was 33.6 mg. A chest x-ray showed the lung fields to be clear, and the heart size was just below the upper limits of normal by cardiothoracic ratio. An electrocardiogram was described as essentially negative.

Treatment was begun for chronic glomerulonephritis with secondary hypertension. The patient ceased vomiting; he lost 6 lbs. in weight, and the edema disappeared with bed rest and a low-sodium diet. The brachial blood pressure dropped to 170/120, but the blood urea nitrogen remained at 126 mg. per 100 cc. Owing to the marked anemia, a sternal bone-marrow aspiration was done three days after admission. With local anesthesia, the operator performed the sternal puncture in the midline of the sternum at the second interspace. The needle was directed at a 15-degree angle into the marrow cavity. No difficulty was encountered. The specimen obtained was reported as peripheral blood.

On the seventh day after admission, the sternal marrow aspiration was repeated. A 16-gauge, short-beveled, 1¼ in. marrow needle was used. The procedure was performed in the midsternal line 1 cm. below the site of the previous aspiration. No difficulty was noted to have occurred, but the operator directed the needle "more deeply in order to avoid obtaining another sample of peripheral blood." The patient later stated that he felt weak and nauseated after the operation was completed, but he did not complain to the house staff until one hour after the sternal puncture. At that time, he vomited and complained of pain in the sternal area, made worse by breathing. No blood was noted in the vomitus, and the patient did not evidence cough or hemoptysis. He was examined by the intern, who recorded his blood pressure as 80/60 and his pulse rate as 65 per minute. Physical examination of the chest did not show cardiac enlargement, diminution of heart sounds, or a detectable increase in the width of the mediastinum. The breath sounds were believed to be depressed slightly over the right anterior thorax.

The patient was placed in Trendelenburg position, and an intravenous infusion of 5% dextrose in distilled water was begun. He received 1/150 grain (0.04 mg.) of atropine subcutaneously. Within 45 minutes after hypotension was detected, the blood pressure had risen to 100/60, but whether the rise was due to atropine or to the intravenous infusion could not be determined. An electrocardiogram was obtained at that time and was interpreted as showing no change from the previous ECG. A portable x-ray of the chest was negative, except for mild cardiomegaly that had been noted previously. The blood pressure again dropped to 90/54, and a transfusion of 500 cc. of whole blood was started two and one-half hours after the sternal puncture. The blood pressure rose to 110/75 after the blood was received and continued in the range of 100/70 to 110/75. The pulse rate remained between 70 and 80 beats per minute. The patient was not dyspneic at any time.

Six hours after the sternal marrow aspiration was done, the heart sounds were noted definitely to be decreased in intensity, cervical venous distention became apparent, and the blood pressure had fallen to 90/60. Fluoroscopy of the chest demonstrated minimal cardiac pulsations. A pericardiocentesis was performed under local (procaine) anesthesia. A long, 18-gauge needle was introduced in the pericardial cavity through the costoxiphoid angle, and 175 cc. of dark blood was aspirated. The blood pressure immediately rose to 145/90. In the next two hours, the blood pressure fell to 105/65, the pulse volume was poor, and the heart sounds were barely heard. The distentions of the neck veins became marked, and a venous pressure was recorded as 260 mm. of saline. Pericardiocentesis was repeated eight hours after the sternal marrow aspiration and yielded 40 cc. of dark blood. The venous pressure immediately after the pericardiocentesis was 235 mm. of saline, and the blood pressure was 135/70.

The patient progressively improved thereafter, with a rising blood pressure and strong heart sounds. The venous pressure was recorded as 195 mm. of saline 10 hours after the sternal puncture. On the following day, a pericardial friction rub was detected and the blood pressure was 150/110. On the second day after the cardiac difficulty, the venous pressure was measured at 160 mm. of saline. Venous pressures were repeated at intervals throughout the remainder of his hospital course and were consistently normal. The bleeding, clotting, and prothrombin times were normal following the episode of tamponade.

Although the treatment of the cardiac tamponade had been successful, the blood urea nitrogen and creatinine continued slowly to rise. The blood calcium fell to 7.8 mg. per 100 cc., and the blood phosphorus rose to 8.2 mg. per 100 cc. on the 25th day after admission. Edema of the hands, presacral area, feet, and legs reappeared, and digitalization did not reduce the edema. The blood pressure continued elevated to 240/138. The high serum potassium persisted and increased to 49.6 mg. per 100 cc. on the 13th day of his hospital course. On that day, he became unconcious, had generalized convulsive movements, and died on Oct. 27, 1951.

Permission for postmortem examination could not be obtained.

COMMENT

The clinical findings in the 13 patients who died after sternal marrow aspiration have been remarkably similar. In general, these patients have exhibited signs and symptoms of circulatory failure, as shown by rapid, weak pulse, low to unobtainable blood pressure, pallor, sweating, dyspnea, and cyanosis. The cerebral hypoxia secondary to the failing circulation quickly dominates the syndrome and is manifested by eye changes, convulsive movements, and respiratory failure. Distention of the neck veins and diminution of the heart sounds may be noted. Death occurred in most of the cases within 10 minutes, although several of the patients survived for 30 minutes. Autopsies have been performed on 10 of these 13 patients and have shown hemopericardium in every instance. The cause of the circulatory failure was presumed to be acute cardiac compression from the intrapericardial blood. The hemopericardium has risen from a laceration of the right ventricle with perforation of its cavity in most of the cases. Two patients † showed only a nonperforating laceration of the myocardium; another [8] showed only a pericardial tear with hemorrhage, and a third [2] had a laceration of the anterior wall of the ascending aorta.

The sternum has been the site of a pathological process, particularly neoplasm, in several of the reported fatalities. In contrast, in this case it appeared normal by clinical examination and by x-ray. Difficulty in obtaining marrow was usually experienced in the cases who died. The operator in our case had no difficulty in entering the sternal marrow but deliberately made the sternal puncture deeper in an unwise effort to avoid a second specimen of peripheral blood. Although most patients died within minutes after the sternal puncture, this patient had a very fortunate slow progression of cardiac compression. An hour elapsed before there was subjective evidence of distress. Six hours passed before he developed the classical syndrome of a quiet heart, venous distention, and hypotension. Such a delay in the appearance of the typical signs and symptoms of cardiac tamponade suggests that the source of the intrapericardial blood was a site of low pressure oozing. Such a site could have been injury to the auricles, intrapericardial veins, retrosternal veins, or the sternum itself, with a laceration of the pericardium only.

The prevention of such a complication as cardiac tamponade after sternal puncture requires strict avoidance of the exertion of force, especially in a sternum which is the seat of a pathological process. The impulse to penetrate deeper if difficulty is experienced in obtaining marrow blood must be repressed. The sternum should not be used as a site for marrow aspiration in young children. In adults consideration should be given to the use of other sites for marrow puncture. The election of the ilium as a site is now more frequently made, but the danger of intraperitoneal penetration is a hazard. Such penetration is minimized by directing the needle downward into the ilium through the iliac crest. The lower end of the tibia is a site that should be associated with a minimum of serious complications. However, sternal puncture is a very valuable procedure in adults, especially if the sternum is involved in a disease process. Performing sternal puncture as high on the sternum as possible, angulation of the needle into the manubrium, or extreme care at a site softened by disease may be safety factors of importance if a needle is used. The use of a needle guard has not always proved to be protection from ventricular laceration.‡ The safety of the routine use of the trephine-type instrument for sternal puncture, and particularly for multiple aspirations, has been emphasized.[11]

If the patient manifests distress after a sternal puncture, primary consideration should be given to the possibility of intrapericardial bleeding. Although the patient may have cardiorespiratory depression from the drug used for local anesthesia, cardiac

† References 4 and 10.

‡ References 2 and 5.

tamponade has been the mechanism of death in the cases who were autopsied. Therefore, it is suggested that any patient exhibiting signs and symptoms of a failing circulation after sternal puncture should have immediate pericardiocentesis. This should be done to exclude the possibility of cardiac tamponade and to treat it if present. The myocardial wound may be of such size that death will ensue before effective treatment of tamponade can be carried out. However, autopsies on some of the fatalities have shown small lacerations which may respond to release of the progressing intrapericardial pressure.

The high degree of success of pericardiocentesis and the ease of performing the procedure in the treatment of acute cardiac tamponade is demonstrated by this case, as has been shown by Ravitch and Blalock.[12] If the patient had not improved so strikingly after the removal of only 40 cc. of blood from the pericardium at the second pericardiocentesis, exploratory pericardiotomy would have been performed. Careful observation for signs of recurrence of the tamponade were made in the 23 days of life after the pericardium was aspirated, but at no time was it implicated in the progression of renal failure and hypertension which led to his death.

SUMMARY

The first reported case of cardiac tamponade following sternal marrow aspiration successfully treated is presented.

Removal of 215 cc. of blood from the pericardium by two pericardiocenteses relieved the cardiac tamponade, but the patient died 23 days later of progression of chronic glomerulonephritis with hypertension and renal failure.

The measures advocated for the avoidance of complications which have resulted in 13 deaths following sternal puncture are reviewed.

Immediate pericardiocentesis in the patient exhibiting signs and symptoms of a failing circulation after sternal puncture is suggested.

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Tumors of the Cheek

Observations on Etiology, Differential Diagnosis, and Methods of Surgical Approach

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The cheek, a definite anatomical area and a distinct body organ, is described by most anatomists in terms couched in generalities.* We will adhere to the description given by Callander,[5] who limits the cheek to that mobile portion of the lateral wall of the oral cavity from the orbit to the mandible and from the masseter muscle to the nasofacial sulcus.

The cheek is covered externally by skin and internally by mucous membrane. Between these two layers (2 to 3 cm. in the average adult) lies muscle, nerve, lymphatic, connective, glandular, vascular, ductal, and adipose tissue, all of which are subject to inflammatory and neoplastic changes.

Space does not permit a detailed description of the anatomy of the cheek. There are some points which will be listed for emphasis. The skin of the cheek is highly vascular and in the male must be considered and utilized as hair-bearing. The subcutaneous tissue is continuous with the buccal fat pad of Bichat. The muscles of the cheek originate peripherally and insert at or near the angle of the mouth. The principal artery of the cheek is the external maxillary artery which courses diagonally across the face. The sensory nerve to the cheek is the trigeminal. The motor innervation is the facial nerve. The parotid duct courses superficial to the masseter muscle and is palpable in most of its course. The mucous membrane has an almost continuous underlying layer of mucous secreting glands (racemose type). The lymphatics of the cheek are drained by the submaxillary and submental nodes. There is an inconstant group of lymph nodes (buccal nodes) at the distal end of the parotid duct.

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* References 1, 2, 3, and 4.

PATHOLOGY AND DIFFERENTIAL DIAGNOSIS

Lesions of the cheeks may be divided into two major groups: (1) those involving the surface coverings of the cheeks and (2) deeper masses in the cheek.

1. *Lesions Involving the Surface Coverings of the Cheeks.*—Basal-cell and squamous-cell carcinoma of the skin of the face are the most frequent malignant conditions of the head and neck,[6] while squamous-cell carcinoma of the buccal mucosa is much less common. Other of the commoner lesions involving the mucous membrane of the cheek are leucoplakia, hemangioma, mucocele, and benign epithelial papillomata. Surface lesions of the skin of the cheek, in addition to cancer, include nevi, hyperkeratosis, verruca, hemangiomata, cutaneous fibromas, cylindromas, and hydradenoma.

These lesions, lying on the surface of an accessible area of the body, should present no problem in diagnosis. In the great majority of cases, an excisional biopsy is the procedure of choice, thereby establishing the diagnosis and completing the treatment in the same procedure. In extensive lesions, the diagnosis should first be made by biopsy and the treatment planned accordingly.

In any surface lesion of the cheek, particularly the skin, it is desirable to remove the lesion because of the possibility of malig-

nant degeneration (hyperkeratosis, nevi, or sebaceous cysts), the problem of growth and spread making later removal technically more difficult (hemangioma), and because an ulcerated area of the cheek presents an easily correctable deformity.

2. *Subsurface Lesions of the Cheek.*—A mass in the cheek between the skin and the mucosal surface presents an exceedingly interesting problem of diagnosis. From a survey of the internal anatomy of the cheek it is apparent that a mass may represent a solid or a cystic tumor arising from any of the several types of tissue present. The cheek mass may originate from the soft tissues of the cheek or it may arise from the underlying bone or dental apparatus.

Fig. 1.—*A*, a 7-year-old white girl with a soft, nontender mass in the right cheek at the nasofacial sulcus present since birth. The mass had grown progressively larger. *B*, the mass was excised through an incision in the nasofacial sulcus. Microscopic examination revealed "neurofibromatosis of left cheek."

Nerve Tumors: Tumefactions of neurogenic origin in the cheek (neurofibroma, neuroma or ganglioma) are exceedingly rare (Fig. 1).

Blood and Lymph Vessel Tumors: Subsurface hemangiomas and lymphangiomas of the cheek are common. They vary greatly in size but generally involve a broad portion of the cheek, rather than presenting as a small isolated mass. These deep lesions are frequently associated with hemangiomatous or lymphangiomatous involvement of the cheek skin or buccal mucous membrane. The lesions are most commonly seen in children or teenagers but occasionally do not become clinically evident until adulthood. They may be either unilateral or bilateral but more commonly involve only one cheek. There is always the history of progression in size of the lesion following its appearance. The patient will frequently volunteer the information that the mass becomes larger and tighter when bending down, as when tying a shoe.

On examination, these masses are always soft and nontender. They are not movable and are poorly outlined, usually merging with the adjacent buccal fat. On bidigital examination of the cheek, the mass is spongy in consistency throughout its extent. Occasionally, localized thrombosis or calcification will produce a palpable nodule. These lesions never produce pressure or obstructive symptoms, such as seventh nerve paresis or Stenson's duct obstruction. Pain is usually not a part of the clinical picture.

Hemangiomas and lymphangiomas can usually be diagnosed from the history and

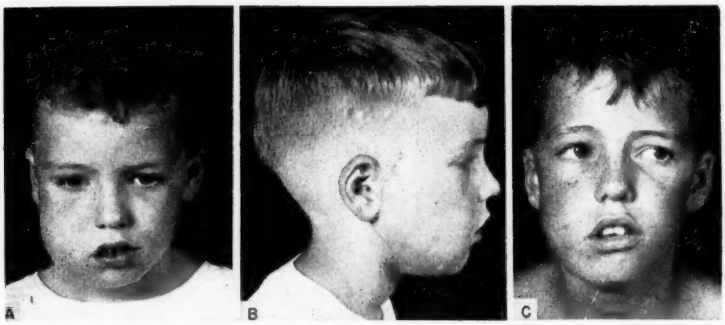

Fig. 2.—*A*, a 6-year-old white boy had a diffuse swelling of the right cheek since birth with progressive enlargement. *B*, the mass was excised in stages, with the use of a combined preauricular-submandibular incision. Microscopic examination revealed lymphangioma. *C*, the result to date.

Fig. 3.—*A*, a 48-year-old white woman had a painless lump in the right cheek for four months. There had been progressive enlargement. *B*, a hemanigoma removed through a paranasal incision (Fergusson).

clinical findings since there is almost always an associated involvement of the surface coverings of the cheeks. Occasionally the diagnosis must be established by biopsy (Fig. 2 and 3).

Hemangioepitheliomas are the malignant variety of this type of tumor and are characterized by their rapidity of growth.

Sebaceous Cysts: These cystic masses are common in and about the cheek and arise as the result of stoppage of the duct of a sweat gland, sebaceous gland, or hair follicle. They are adherent to the under surface of the skin, and enlargement is at the expense of the underlying loose connective tissue. The overlying skin will frequently reveal degenerative changes, such as atrophy and loss of tone, owing to prolonged pressure from below. They may present as any size mass up to about 5 cm., but seldom larger, since the increased intracystic pressure produces atrophy of the secreting epithelium. On examination,

fluctuation is frequently not present because of the usual chronicity with its associated pericystic inflammatory fibrotic reaction and because of the usual high intracystic pressure. These tumefactions are not movable under the skin but can be moved freely with the adherent skin over the underlying subcutaneous tissue.

Sebaceous cysts should be differentiated from cutaneous fibromas which arise from the connective tissue of the dermis and are, therefore, wholly within the skin. This difference is important, since it precludes the possibility of transoral excision of the cutaneous fibroma.

Sebaceous cysts should be excised early because of the incidence of malignant degeneration (5%)[5] and because of the deformity produced by their presence. This deformity is always increased when these cysts become infected and require incision and drainage with later excision. This is a rather common occurrence in sebaceous cysts.

Dermoid Cysts: These benign cystic structures are congenital defects produced by inclusion of epithelium at the closure of the embryonic clefts. The only location involved on the cheek is in the region of the nasolabial fold. They vary in size up to about 6 cm. and are found to be subcutaneous and, therefore (unlike sebaceous cysts), freely movable under the skin. They are usually asymptomatic and make their appearance in childhood or young adult life. The incidence of malignant degeneration is lower than for sebaceous cysts.

Lipoma and Liposarcoma: These tumors are uncommon in the cheek. This seems strange, since there is relatively more adipose tissue in the cheek than in most other parts of the body. However, they do occur and their diagnosis is difficult to make. Lipomas arise from the subcutaneous fat and from the buccal fat pad and enlarge inward or outward, depending on their point of origin. The enlargement is insidious, and the patient is usually unaware of the mass until it has reached considerable size. The lipoma, since it originates from the cheek fat, is in intimate contact with the adjacent soft tissues of the cheek and presents as a soft generalized enlargement rather than as a discrete mass. Examination reveals a cheek that is usually enlarged, normal in consistency, and nontender. There is asymmetry of the cheeks, the involved side being the larger. There is a distinct difference in palpation between a lipoma and an angioma, the angioma being softer and more compressible. Palpatory comparison of the normal and involved cheek is a great aid in determining the extent of the tumor. These tumors are very slow-growing. They should be removed because of the deformity but more important because of the possibility of malignant degeneration (10%).[5]

Liposarcoma is a rare condition in the cheek. It cannot be diagnosed with certainty except by microscopic tissue examination, but a history of sudden, rapid growth in a soft mass of the cheek should raise one's index of suspicion as to the possibility of malignancy. Although these tumors are of low-grade malignancy and seldom metastasize, they will recur locally if not completely removed.

Accessory Parotid Salivary Gland Tumors and Tumors of the Parotid Duct: Although the parotid gland lies predominantly outside the limits of the cheek, the anterior extension along Stenson's duct (the so-called tail of the parotid) and the accessory parotid gland located at variable points along the parotid duct are usually within the anatomic limits of the cheek.

This tissue is subject to the same inflammatory processes and neoplasms as are found in the bodies of the principal salivary glands. A mass at the anterior border of the masseter muscle, adjacent to the parotid duct, is the usual position of a tumor of the accessory parotid gland. Cancer of the parotid duct can arise anywhere along the course of the duct but most commonly arises in the distal half.

The diagnosis of these tumors is difficult to make. Positive diagnosis is made only from microscopic tissue examination, but there are certain aids to diagnosis which can sometimes be of assistance. Sialograms of the parotid

salivary gland and duct will visualize the position of these structures and reveal any deviations from the normal (Fig. 9*B*). Since the parotid duct is palpable in most of its course and since it can readily be visualized on sialograms, it serves as the principal landmark of the internal anatomy of the cheek. Visualization of the parotid duct should be a routine diagnostic procedure in any mass in the cheek. For technique and interpretation of findings, the reader is referred to the excellent monograph by Blady and Hocker.[8]

Generally, stoppage of the parotid duct will produce pain and swelling in the parotid gland. The degree of pain and swelling is directly proportional to the secretory activity of the gland and the extent of the obstruction. Thus, a calculus of the parotid duct is more likely to produce acute symptoms due to sudden, complete obstruction than is a cancer of the duct which will obstruct in a more gradual fashion.

Cancer of the parotid duct produces symptoms and signs of obstruction early. There is an associated palpable mass along the course of the duct, and sialograms reveal an obstruction of the duct at the level of the mass.

A tumor of the accessory parotid gland, whether it be benign or malignant, will produce a palpable mass near the anterior border of the masseter muscle, but obstructive signs are usually not present. Sialograms reveal deviation of the parotid duct in the region of the mass but no obstruction.

Aberrant Salivary Gland Tumors: Since salivary gland tissue arises from the epithelium of the primitive oropharynx, the location of aberrant salivary gland tumors can occur anywhere in the cheek. The size of the mass varies but it seldom exceeds 2 to 3 cm. in diameter. These tumors are characterized by their slow growth, nodularity, and absence of pain. They occur in any age group but are more commonly seen in young adults. In the cheek, these tumors present as firm, nodular masses, freely movable and nontender. They are most frequently located near the distal end of the parotid duct in the region of the accessory parotid gland. They may occur in the skin or mucous membrane of the cheek, where they appear as small masses, fixed to the surface.

Tumors of aberrant salivary glands are most commonly mixed tumors. They may also be cystic or solid adenomas. The inci-

Fig. 4.—*A*, a 14-year-old Negro boy with a mixed tumor of an aberrant salivary gland of the right cheek. This had previously been excised elsewhere, through an incision made immediately beneath the mass. *B*, the mass was removed by excising the previous scar.

dence of malignancy in mixed tumors of aberrant salivary tissue is 33%.[9]

It is impossible to diagnose an aberrant salivary gland tumor in the cheek positively without microscopic examination.[10] Since they occur most commonly in the midcheek region, they may be confused with cancer metastatic to the buccal lymph nodes, carcinoma arising from the parotid duct, or carcinoma of the accessory parotid gland. These masses should be excised (Figs. 4 and 5).

TREATMENT

Surface Lesions.—Lesions involving the surface coverings of the cheek present no problem. Whether the lesion involves the skin or the oral mucous membrane, excision is performed as indicated. Usually, in small lesions, an excisional biopsy is the procedure of choice. Closure can ordinarily be made by simply approximating the edges of the defect, but in some instances, depending on the size, it will be necessary to mobilize the wound edges to obtain satisfactory closure. In other instances it will be necessary to resurface the defect with an adjacent flap.

In the event that it becomes necessary to close an external defect with a flap, the simplest procedure is usually the best. The French type (sliding) flap offers the easiest repair and produces no added disfigurement. This is a method which utilizes the redundant skin of the neck to replace the excised skin of the cheek. Advancement of the cheek skin is desirable, since the color, texture, and thickness are identical, and the reservoir of available skin is large. Advancement of the neck skin to the face produces no cosmetic disfigurement. In cases involving large defects, the resulting tension is soon relieved, owing to the elasticity of the skin. In elderly patients in whom much of the elastic quality of the skin is lost, a modified face lift on the contralateral cheek is sometimes desirable for symmetry.

Subsurface Lesions.—Intraoral vs. Extraoral Approach: In the removal of a lesion lying in the substance of the cheek and involving neither surface covering, the operator has the choice of intraoral or extraoral removal. The choice is dependent primarily on the suspected nature of the mass. If malignancy is expected, the mass should be exposed in such a way that radical surgical excision can be performed immediately upon receipt of the pathologic diagnosis, by extension of the biopsy incision.

However, when the mass is small and freely movable and malignancy is not strongly suspected, it can be removed by either route, depending on its position. We feel that masses lying superficial to the buccinator fascia cannot be removed by the transoral route without danger of poor exposure and increased

Fig. 5.—*A*, a 65-year-old Negro had a painless mass in the left cheek for eight years. It had grown slowly in size. *B*, the mass was removed through a paranasal (Fergusson) incision. Microscopic examination revealed a mixed tumor of an aberrant salivary gland. *C*, postoperative result.

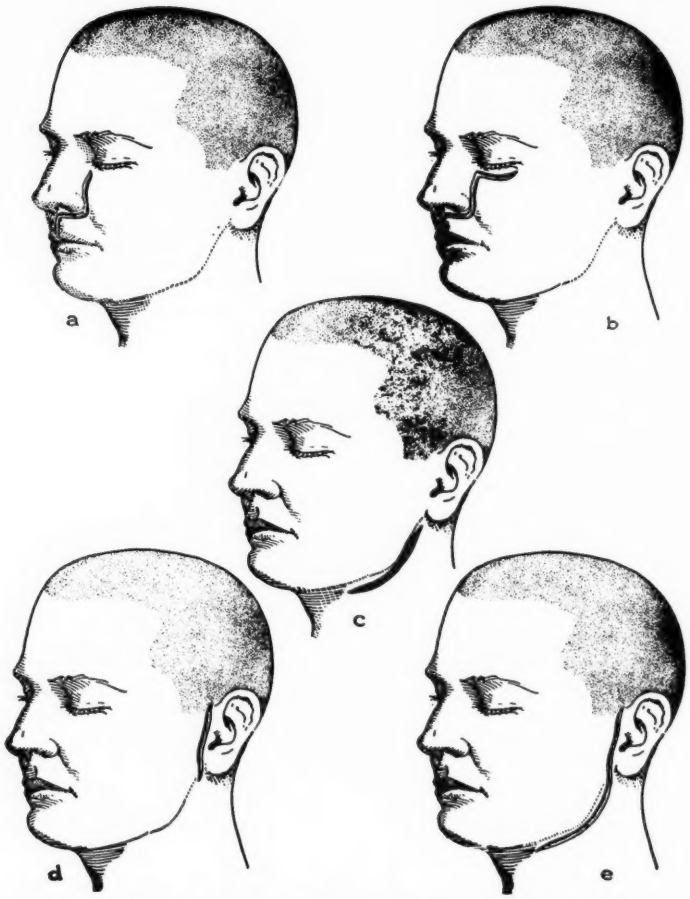

Fig. 6.—(*a*) Paranasal incision, Moore type; (*b*) paranasal incision, Fergusson type; (*c*) submandibular incision; (*d*) preauricular incision; (*e*) preauricularsubmandibular combined approach.

possibility of damage to the branches of the facial nerve. When the mass is deep to the buccinator fascia, the excision is carried out by incising the mucous membrane, exploring and removing the mass, and closing the defect in layers. Care must be taken to identify and preserve the parotid duct.

In the extraoral approach to masses of the cheek, the surgeon has a choice of several procedures. Again, the choice will be governed by the surgeon's index of suspicion of cancer, the size and location of the mass, the age and sex of the patient, and the history and physical findings.

(*a*) Direct Approach: Incision of an unscarred cheek is usually not justified. The presence of scars or skin lesions which require excision serves as a portal for exploratory procedures on the cheek.

(*b*) Paranasal Approach: These incisions, in which the skin of the cheek is reflected laterally, serve as excellent methods of producing adequate exposure of the cheek and, at the same time, leaving minimal residual deformity (Figs. 6*a* and *b*).

In both the upper lip is incised through its full thickness, in the midline up to the base of the columella and carried laterally around

the ala of the nose, with care to leave sufficient skin lateral to the ala for accurate closure. The incision is then carried superiorly along the nasofacial junction to approximately 2 cm. below the inner canthus.

In the Fergusson incision a transverse limb extends laterally to the outer canthus. This transverse incision is made along the junction of the cheek and the lower lid.

After the skin incisions have been made, dissection is carried down to the periosteum of the maxilla, and the entire substance of the cheek is reflected laterally. The mass is then removed retrograde, from the inner aspect of the cheek.

(*c*) Submandibular Approach (Fig. 6*c*): This approach, in which the incision is made on the neck under the mandible, provides excellent exposure with minimal residual deformity. The incision can extend from the symphysis menti to the lobule of the ear. The dissection is carried down to the platysma muscle and up onto the face in the same plane. In this way, injury to the branches of the seventh nerve is minimized.

(*d*) Preauricular Approach (Fig. 6*d*): This type of incision is seldom applicable for masses of the cheek. Conceivably, it could be used to excise masses at the extreme lateral limits of the cheek or in cases in which exploration of the parotid duct is desirable, but generally it provides inadequate exposure and is not recommended for excision of cheek masses.

(*e*) Preauricular - Submandibular Combined Approach (Fig. 6*e*): This incision, as presented by Blair and Pady,† increases the advantages of the submandibular approach with minimal deformity. The incision is made on the neck under the mandible and carried behind the angle of the mandible upward in front of the ear to the level of the zygomatic arch. For exploratory procedures on the cheek, the dissection would be limited in depth to the subcutaneous fat, and the flap created would be reflected medially, thus producing excellent cheek exposure.

† References 12 to 25.

(*f*) Suborbital Approach (Our Method) (Fig. 7): Since the cheek is a smooth surface without natural folds, it is desirable to limit incisions to the periphery. For adequate exposure, extensive undermining of the cheek skin is necessary, and therefore all available blood supply must be maintained. In exploratory procedures on the cheek, it is desirable to reflect only the skin and subcutaneous tissue, and full-thickness reflection of the cheek or lip is neither necessary nor desirable. For these reasons, it is felt that all of the previously described incisions, although excellent for their intended purposes, are not completely suitable for cheek explorations. The following procedure is submitted as a desirable incision for operations on the cheek which cannot be adequately explored through simpler incisions.

Fig. 7.—Suborbital approach (Authors' method).

The incision is begun just lateral to the alar wing of the nose. It then extends superiorly along the nasofacial crease to a point approximately 2 cm. below the inner canthus. It is then carried laterally along the junction of the lower lid and skin of the maxillary area to a point just lateral to the outer can-

thus (Figs. 8*A*, 8*B*, 9*C*). The incision is then extended across the zygomatic area to the ear and thence along the auriculofacial junction to the angle of the mandible (Figs. 8*A*, 9*C*). The area of skin thus outlined is elevated from the underlying tissues and turned down to expose the entire substance of the cheek (Figs. 8*A*, 9*C*). If additional exposure is needed, the incision can be extended under the mandible to the external maxillary vessels and along the nasolabial groove to the commissure of the mouth.

This method of exploring cheek masses is thought to have several advantages:

(*a*) Exposure: It is a basic surgical principle that antegrade approach to a mass is preferable to the retrograde approach. This method, utilizing this principle, gives widespread exposure of the cheek so that any mass can be explored and excised in a forward direction.

(*b*) Cosmetic Results: In all types of incisions, the resulting scar is usually offensive in some manner. The paranasal incision produces a noticeable mid-lip deformity, which, since it is located in the central face region, is distinctly undesirable. We have been impressed with the absence of deformity from incisions along the nasofacial groove, infraorbital area, and auriculofacial junction. Thus, it was felt that if these three desirable components of peripheral cheek incisions could be combined and at the same time the mid-lip scar be omitted, a more desirable result would be obtained. Thus, we have transferred the mid-lip deformity to the lateral face, connecting the infraorbital and auriculofacial components and at the same time have increased the amount of exposure, since the mid-lip and infranasal arms of the Fergusson incision add nothing to the exposure in antegrade explorations. It is noted that the lateral visible facial scar can be made to lie in the area usually covered by the frame of glasses.

(*c*) Morbidity: As previously stated, reflection of the entire substance of the cheek is neither necessary nor desirable in exploring cheek masses. Full-thickness reflection of the cheek produces marked swelling and unnecessary postoperative morbidity in addition to the fact that the oral cavity is entered with subsequent contamination of the operative field. When only the skin and subcutaneous tissues of the cheek are reflected, there is minimal postoperative edema, and a pressure type of dressing is applied for only 24 hours.

(*d*) Anesthesia: Operations requiring manipulation about the bony maxilla, such as in the Fergusson and Moore approaches, require endotracheal anesthesia. The proposed suborbital incision is done with the patient under local anesthesia.

(*e*) Vascularity: Vascular supply to the operative area has not presented a problem in any of the operative procedures mentioned. In the suborbital approach, the viability of the cheek flap is excellent if care is taken to preserve the continuity of the external maxillary vessels.

(*f*) Malignancy: If a malignant tumor is found at operation, it is handled in the usual manner; i. e., wide local excision, with radical neck dissection, if indicated, four to six weeks later.

SUMMARY

Lesions of the cheek are discussed as to etiology and differential diagnosis. Various methods of treatment are discussed and a new approach offered.

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Fig. 8.—*A*, a 22-year-old white man with multiple sebaceous cysts of the left cheek. Excision would have required several cheek incisions. The suborbital approach was used. *B*, seven sebaceous cysts were removed from the undersurface of the cheek. *C*, two months postoperatively.

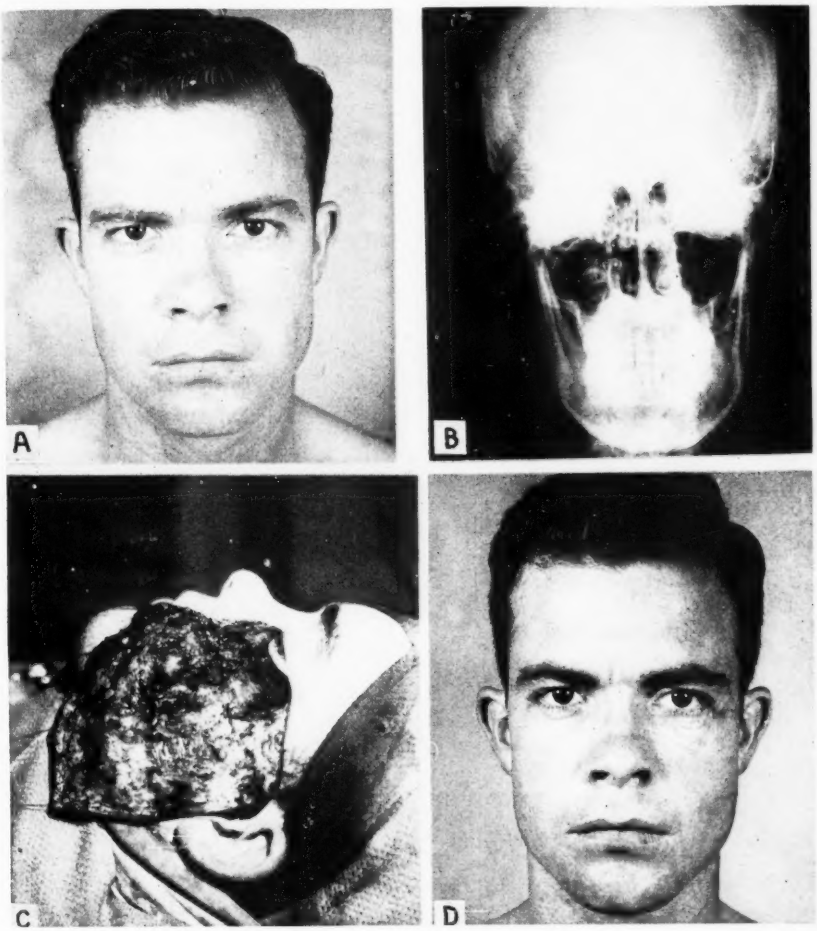

Fig. 9.—*A*, a 22-year-old white man gave a history of a painless mass in the left cheek for four years. The mass was firm to palpation. *B*, sialogram of the left parotid duct revealed no obstruction but marked deviation, laterally. The preoperative diagnosis was mixed tumor of an aberrant salivary gland. *C*, exploration through a suborbital incision revealed a large sebaceous cyst which was tense and firm. The superior labial branch of the facial nerve was adherent under the cyst. The defect in the cheek was filled with an adjacent fat graft. (*D*), three months postoperatively.

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Anesthesia and Supportive Therapy During Mitral Commissurotomy

Experience in One Hundred Eighty-Seven Operations

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This communication is concerned with the experience at the Mayo Clinic in the anesthetic and supportive management of patients undergoing operations on the mitral valve prior to and through the year 1954.

From 1951 to 1954 inclusive 187 operations were performed on 185 patients. Two patients had symptoms of recurrence of mitral stenosis following apparently successful valvotomy and underwent second operations, respectively 15 and 41 months after the original operations. The degree of functional impairment was determined before every operation according to the classification of the New York Heart Association.[1] This can be condensed as follows: impairment, Class I, none; Class II, slight; Class III, marked; Class IV, extreme (Table). Of our 185 patients, 56 were male and 129 were female. They ranged in age from 14 to 59 years.

TABLE.—*Cardiac Function* as Determined Before Each of 187 Operations on 185 Patients*

Functional Class	Operations, Number
I	3
II	44
III	93
IV	47

* New York Heart Association classification.

Three patients suffered from multiple cardiac lesions, one of which was mitral stenosis in each case. Following mitral commissurotomy, but at the same operation, one of these three patients underwent repair of an atrial septal defect; another, tricuspid commissurotomy, and the remaining one, insertion of a Hufnagel valve for aortic insufficiency. A fourth patient had severe symptoms of intermittent claudication attributable to an embolus at the bifurcation of the aorta suffered three years prior to performance of the mitral commissurotomy. Six months after successful correction of her mitral lesion, she underwent uneventful resection and grafting of the terminal portion of the aorta.

In the service of which I am a part, the surgeon, cardiologist, physiologist, and anesthesiologist comprise a team within which free exchange of ideas and information is encouraged. For this reason I shall use the first person pleural sometimes. As the team matures with experience, individual members assume responsibilities related to their interests and skills. The obligations undertaken by the anesthesiologist include those of ordering drugs for preoperative sedation and, of course, of administering the anesthetic agents. In addition, he is responsible for estimating circulatory and respiratory efficiency during the operation. Deviations from a physiologic state are treated by him with appropriate drugs, fluids, or blood, as the case may require. In the cases on which this paper is based, the anesthetic management was almost all under the direction of Dr. John W. Pender, Dr. Roger W. Ridley, or me.

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PREPARATION OF PATIENT; INDUCTION AND MAINTENANCE OF ANESTHESIA

The status of all patients was reviewed by one or more cardiologists before operation. The responsibility for realization of the best possible condition for the individual patient was assumed by the cardiologist, and he, with the surgeon, decided on desirability of, and optimal time for, surgical measures.

The variety of agents and techniques used successfully for anesthetic* management of patients who undergo the operations considered herein precludes dogmatic statements in regard to such methods of management. That technique which in the hands of the individual anesthesiologist affords the most efficient circulation of oxygenated blood will be the most valuable in his hands.

In the cases here concerned an anesthesiologist visited all patients the evening before operation, reviewed pertinent features of the history and physical findings, and ordered appropriate preoperative medication. All patients were given 8 to 15 mg. of morphine sulfate, or a comparable dose of another narcotic, hypodermically approximately 45 minutes before induction of anesthesia. Most patients also received 100 mg. of pentobarbital sodium by mouth the morning of operation. Four patients early in the series received atropine sulfate, but this practice was discontinued when it was found that secretions were not troublesome; also, it was assumed that tachycardia would be less frequent if atropine were omitted.

Anesthesia was induced in all cases with nitrous oxide, oxygen, and ether; the concentration of oxygen was 20% or more. Five patients received 125 mg. of thiopental sodium (Pentothal Sodium) intravenously as an aid to induction. Moderate preoperative sedation is desirable for tranquil induction with these agents, and, in turn, quiet induction without hypoxia is mandatory for patients with severe heart disease. In the course of induction, the alveolar oxygen concentration is at its lowest of the entire anesthetic period, and breath holding, coughing, and laryngospasm should be averted if at all possible. As the first or second plane of anesthesia was reached, use of nitrous oxide was discontinued. After inhalation of ether and oxygen for several minutes, a cuffed endotracheal tube was inserted. Anesthesia was maintained with ether and oxygen, and respiration was assisted, or in a few cases controlled, by manual compression of the breathing bag while the pleura was open.

The lung on the exposed side was gently retracted by the surgeon and was not permitted to become completely deflated. In no instance did the state of the patient become so precarious that the contemplated surgical procedure could not be completed. Surprisingly, acute pulmonary edema did not occur during induction or maintenance of anesthesia, although each of many patients gave a history of such episodes occurring with exertion or at previous unrelated operations. In some patients depth of anesthesia was monitored by means of continuous electroencephalographic recording, and in these patients it was found that ether level I or II was adequate for the procedure.[10]

SUPPORT OF CIRCULATION

The more pressing problem of the anesthesiologist was maintenance of satisfactory circulation during the operation. The cardiac output of patients with mitral stenosis frequently is fixed and reduced; they are unable to compensate well in response to increased tissue demand or to peripheral vasodilation. Such vasodilation may result from deep anesthesia with ether along with some additional decrease in myocardial efficiency.[11] Accordingly, anesthesia was maintained at the lightest level suitable for the surgical procedure. Hypotension, or a systolic blood pressure of less than 80 mm. of mercury and of more than a few minutes' duration, was observed in 52 cases. Blood pressure in these cases usually decreased to a basic level of 70 or 80 mm. of mercury, where it stabilized and remained until valvotomy had been performed or until the pleura had been closed. Then pressures

* References 2 to 9.

approaching preoperative levels usually were observed.

Six patients were given vasopressor drugs. More commonly anesthesia was lightened and an expectant policy was adopted, because we believed that the true circulatory status could be masked by artificial support with drugs. Extreme hypotension, of course, was noted with massive hemorrhage or during the time that the mitral orifice was blocked by the surgeon's manipulations. The former was treated by infusion of blood; the latter, by warning the surgeon if occlusion of the orifice was prolonged. Cessation of manipulation was almost always followed by return of adequate blood pressure.

As part of the effort to maintain circulatory efficiency, an attempt was made in all cases to estimate the amount of blood lost by weighing used sponges and collecting aspirated blood in graduated suction bottles. To avert circulatory overloading, blood given in the course of operation was deliberately 200 or 300 cc. less than the estimated amount lost. To 157 patients 500 cc. or 1000 cc. of blood was given and to the remainder larger quantities or none. Loss of blood was greater if the atrial appendage was filled with thrombi and if it was necessary for the surgeon to approach the valve through the atrial wall rather than the appendage.

VARIATIONS IN CARDIAC RATE AND RHYTHM

Tachycardia, or persistence of a cardiac rate greater than 100 beats per minute, was observed in 43 cases. Here again a policy of waiting usually was rewarded by a reduction in rate after valvotomy had been done. Lanatoside C in doses of 0.2 to 0.4 mg. was given intravenously to four patients, all of whom had been digitalized before operation.

Electrocardiographic tracings were made at intervals on all patients. Arrhythmias of many kinds were common; those which were potentially serious were frequent ventricular extrasystoles or short bursts of ventricular tachycardia. In no case did these persist sufficiently to be alarming and no patient received procaine hydrochloride or procainamide hydrochloride intravenously. Early in our experience at the clinic lidocaine hydrochloride in a concentration of 2% was injected into the pleura and pericardium before incision of these membranes; this was done in 21 cases. The practice was discontinued after our failure to demonstrate that it was of any value in preventing arrhythmias. Neither ventricular tachycardia of more than a few seconds' duration nor ventricular fibrillation was observed.

Auricular fibrillation was found in examination of 80 patients before operation. All of these patients had been receiving a preparation of digitalis or were digitalized as part of their preparation for operation. The onset of slow auricular fibrillation in the course of operation was noted in one case at the time of placement of a clamp on the atrial appendage. In 23 cases auricular fibrillation developed while patients were in the hospital after operation.

The existence of auricular fibrillation, with or without a history of previous embolic phenomena, indicated that there was an increased hazard of operative or postoperative cerebral embolus.

Eighty operations were performed on 79 patients with one or both of these antecedent conditions. Cerebral embolus occurred in the course of five operations and after eight. The presence of cerebral embolism was manifested in two of these instances by mental confusion lasting a few days. In these two instances recovery was complete. In six instances recovery was accompanied by lasting neurologic defects, and in five instances death occurred.

Seven operations were performed on patients with histories of previous embolic episodes, but auricular fibrillation was not present at operation; in these instances cerebral embolism did not occur.

The remaining 100 of the 187 operations were performed on patients who did not give histories of embolic episodes and did not have auricular fibrillation at the time of operation. In the course of 4 of these 100 operations, however, cerebral embolism occurred but was not fatal. Flaccidity of one

arm and one leg lasting 30 minutes was the only manifestation of embolism in one case.

In our early experience we occluded the carotid arteries briefly during intracardiac manipulation if cerebral embolism was feared. It soon became obvious that embolism could occur at any time in the operation or in the immediate postoperative period, and carotid occlusion was discontinued.

OTHER COMPLICATIONS DURING OR AFTER OPERATION

Two patients failed to survive the operative procedure itself. The first of these was a woman, 41 years old, whose functional classification was IV. Her atrial appendage was filled with thrombi, and, at the moment of valvotomy, cardiac arrest occurred and resisted all attempts at resuscitation. Postmortem examination revealed the presence of fresh emboli in both middle cerebral arteries. The other patient, also a woman, was 54 years old; her symptoms placed her in functional group III. Since the atrial appendage was filled with thrombi, entry was effected through the atrial wall. Sudden massive hemorrhage occurred and heart action became feeble. Rapid infusion of 6500 cc. of blood, cardiac compression, and intracardiac injection of calcium gluconate and epinephrine temporarily created an effective heart beat with a palpable peripheral pulse. However, the heart gradually failed and death occurred, in spite of all further attempts at resuscitation. In retrospect, it is recognized that circulatory overloading may have occurred. This is the only death in the entire series to which anesthesia or supportive therapy may have contributed.

The occurrence of cardiac arrest was associated, in two additional cases, with massive hemorrhage during approach through the atrial wall. Successful resuscitation was effected by replacement of blood and cardiac compression with intracardiac injection of calcium gluconate and epinephrine. Cardiac arrest was noted in one case at the moment of valvotomy. Immediate recovery followed momentary cardiac compression. Ventricular fibrillation was not observed in the entire series.

Postoperative complications related to anesthesia included atelectasis confined to one lobe in four cases. Recovery was complete after coughing had been encouraged, antibiotics had been administered, and tracheal aspiration had been effected by catheter in three cases and by bronchoscopy in one. A postoperative roentgenogram of the thorax revealed collapse of the right lung of one patient; this was successfully treated by placement of an intrapleural drainage catheter. One patient suffered from hoarseness following operation; at suspension laryngoscopy nine months after valvotomy a granulomatous lesion, presumably due to endotracheal intubation, was removed from a vocal cord. Mild, transient jaundice in one case apparently was caused by reaction to blood transfusion.

Severe mitral insufficiency, with minimal or no mitral stenosis, was discovered at operation on seven patients. Of these, one died in the postoperative period of progressive cardiac failure. A similar death occurred in one case in which mitral stenosis was incapacitating and the valve was inaccessible because of thrombi in the left atrium and appendage. This lends evidence to the impression that patients who undergo surgical operation directed toward a cardiac lesion and whose dominant lesion cannot be corrected are less likely to survive than those whose cardiac status has been improved by the operation.

SUMMARY

From 1951 to 1954 inclusive, at the Mayo Clinic, 187 operations were performed on 185 patients, with the purpose of relieving mitral stenosis. Patients ranged from 14 to 59 years of age; about a third were males. Approximately three-fourths of the patients were severely incapacitated before operation. Anesthesia was designed to give quiet induction, quiet maintenance, and maximal oxygenation. Therefore, preoperative sedation was followed by induction of anesthesia with nitrous oxide, oxygen, and ether and this by maintenance with ether and oxygen.

Blood, partly to replace that lost, was administered in the course of operation. Greater reliance was placed on assuring oxygenation and light anesthesia than on administration of drugs to sustain adequate circulation. Complications included hypotension, variations in cardiac rate and rhythm, cardiac arrest, and atelectasis. Two patients died in the course of operation.

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Pulmonary Embolism from Occult Phlebothrombosis

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This report describes the occurrence of pulmonary embolism as a first manifestation of thrombotic disease in ambulant persons. It does not deal with the all-too-common event of such emboli arising in those confined to bed after surgery, childbirth, or serious illness, nor with those who are aware of some injury, swelling, or other abnormality in their legs, nor yet with the well-recognized group of cases in which pulmonary emboli are a first sign of malignant disease. American literature includes a few descriptions of embolic incidents of the type in question, arising from so-called "spontaneous" thromboses (Homans [1] and Naide [2]), but I am not aware of a similar account from English sources. The cases reported by Simpson,[3] however, in which pulmonary emboli caused death in persons who had sat in deck chairs for long periods in air-raid shelters, are in some respects comparable.

REPORT OF CASES

CASE 1.—A factory worker aged 47 came home from work complaining of pain in his chest. His physician observed that he was very short of breath and had a cough with blood-stained sputum. He had no complaints referable to his legs. When examined five days later, having rested in bed meanwhile, he had a few crepitations in the right axilla, a normal heart, a blood pressure of 130/80, and normal legs.

He was admitted to the hospital with a tentative diagnosis of carcinoma of the bronchus. Chest x-ray showed an opacity in the right lower zone, reported by the radiologist as probably pneumonic. Shortly after this, 12 days after stopping work, the patient developed a paroxysm of dyspnea while using a bedpan and died. Postmortem examination showed a massive embolus in the main trunk of the pulmonary artery and some smaller, older emboli that had led to infarction of the right lung. The right femoral and the left posterior tibial veins contained antemortem thrombi, and on microscopy the vein of the left soleus muscle showed laminated clot. No evidence of carcinoma or other serious disease was found.

CASE 2.—A 50-year-old canteen waitress came home from her job feeling so short of breath that she was hardly able to walk across the room. She had no swelling or pain in the legs. Two days later, when she was seen in consultation, the dyspnea was improving, and the finding of an apical triple rhythm and a blood pressure of 75/60 led to the suspicion of a painless myocardial infarct. An electrocardiogram, however, showed unmistakable evidence of acute cor pulmonale—right axis deviation, Q- and inverted T-waves in lead III, tall R in V_1, and clockwise rotation. The lungs were clinically normal, but a chest x-ray was not obtained.

Anticoagulant treatment was begun, but she died the next day. Postmortem examination showed a large embolus in the right pulmonary artery, a smaller one in the left, and an older infarct in the right lower lobe. Antemortem clots were present in the popliteal, femoral, and iliac veins of both legs. There was no evidence of a myocardial infarct or carcinoma.

CASE 3.—An engineer aged 49 was admitted to the hospital complaining of severe shortness of breath, which had come on suddenly five days earlier. Ten days before admission he had felt a pain in his chest while eating a meal. During the previous two years he had had epigastric and substernal pain attributed to dyspepsia; an electrocardiogram a year before admission had been normal. He had never had pain or swelling in his legs.

Examination showed marked dyspnea, creptitations at the bases of both lungs, blood pressure of 105/80, filling of the jugular veins, and enlargement of the liver. His legs were not swollen; his calves were not tender, and Homans' sign was negative. Electrocardiogram showed no evidence of

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coronary disease, but there was a deep S-wave in lead aV_L which had not been present in the earlier tracing and was taken to indicate a more vertical heart position. Chest x-ray showed midzone opacities in both lungs and a small effusion at the left base; it was reported as showing passive congestion. He was treated with digitalis, salt restriction, and penicillin but died in cardiac failure early in the second week.

Postmortem examination showed multiple pulmonary emboli and bilateral antemortem thrombosis of the deep veins of both legs. The right side of the heart was dilated; the coronary arteries were narrow and calcified, and the apex of the left ventricle was thin and fibrotic, with an adherent mural clot. No evidence of carcinoma was seen. Ischemic heart disease complicated the picture, but the terminal illness and death were clearly due to emboli from unsuspected phlebothrombosis.

CASE 4.—A male nurse aged 47 was admitted to the hospital with pain in the left side of the chest that was worse on breathing and hemoptysis, both of which had come on suddenly two days before. He had no complaints referable to his legs. Examination showed slight fever (99.6 F), bronchial breathing in the left axilla, a normal heart, and blood pressure of 145/70. A chest x-ray revealed an opacity in the left lower lobe, described as consolidation, and the white blood cells numbered 19,400 per cubic millimeter, 71% being polymorphonuclear cells. He was regarded as suffering from pneumonia and treated first with a course of penicillin, later with chloramphenicol, and lastly with chlortetracycline. His response was not satisfactory, and signs of consolidation appeared on the opposite side of the chest, followed by a small spontaneous pneumothorax. Three further x-rays and screening of the chest did not assist the diagnosis. The successive courses of treatment occupied a month, during which time he had five separate exacerbations of fever, chest pain, and hemoptysis, each gradually resolving without any clear relation to the chemotherapy.

A month after admission, when seen by me, he complained for the first time of pain in his right leg. The leg appeared normal, but this, taken with the history and the temperature chart, led to treatment with anticoagulants, on the hypothesis that phlebothrombosis in the leg, giving rise to recurrent emboli, might be the underlying cause of the illness. Ethyl biscoumacetate, in dosage controlled by prothrombin time estimations, was given for two weeks, during which time the fever subsided and he had no further chest pain or hemoptysis. After treatment was stopped, he was well for four weeks, being discharged from the hospital, but then a recurrence of exactly similar symptoms led to his readmission. On this occasion he had bilateral pulmonary consolidation with pleural effusions, but the legs, in spite of the most careful examination, gave no sign of abnormality. Once more he responded to the same anticoagulant, and it seemed that emboli arising from his leg, most probably from the right, were the cause of the chest condition. Supporting radiological evidence was obtained from a phlebogram, which showed normal filling of the deep veins of the left leg but no such filling with a similar technique on the right. Surgical consultation was then requested, and Mr. A. York Mason tied the right femoral vein. Since then the patient has had no recurrence of symptoms, and, although he was warned that operation on the other leg might be needed, this has proved unnecessary.

The hypothesis here lacks anatomical proof, but the response to treatment leaves little doubt that recurrent pulmonary embolism from the outwardly normal leg was taking place, just as in the first three patients.

COMMENT

These cases are reported to emphasize the point that serious or fatal emboli may arise from the venous system of apparently normal legs in ambulant persons not known to be suffering from disease. Twenty years ago, Homans [4] made the same observation, but it is still widely ignored. At present stasis in the veins is regarded as an important factor in the development of phlebothrombosis, and the postoperative management of surgical patients is largely influenced by the desire to avoid such stasis. Many have, therefore, sought for a similar cause in the "spontaneous" phlebothrombosis. Simpson's [3] explanation has already been noted. In a recent paper Homans [5] implicates long-distance travel in cars or aircraft as a cause of stasis. Naide [2] regards such thrombosis as an especial risk of tall men. The subjects of the present communication were not notably tall, and their daily work, in which they were engaged up to the time that they became ill, did not involve anything that appeared likely to impede the venous return from their legs. It seems, therefore, that the factor of stasis was not important and that investigation into local abnormalities of the veins or increased coagulability of the blood might have been of more interest.

The clinical manifestations of this condition will depend on the size of the emboli, small ones giving rise to pleural pain, hemop-

tysis, and radiological changes, large ones giving rise to dyspnea, acute or subacute cor pulmonale, and electrocardiographic abnormalities. The electrocardiogram was, in fact, diagnostic in Case 2, but this is unusual. Chest x-ray changes are variable and not always characteristic. In addition to the type of opacity commonly attributed to an infarct, there may appear pleural effusion, cavitation, or spontaneous pneumothorax. In one of my cases, not described here, the appearance of the chest x-rays was dominated by an aneurysm of the right branch of the pulmonary artery, which had developed proximal to an embolus. Diagnosis must rest on accurate interpretation of the clinical history and is most likely to be successful in the thrombosis that sheds small emboli over a long period, as in Case 4. The combination of pleural pain, hemoptysis, and fever after surgical operations was described as pneumonic for years before the true incidence of embolism was established. Similar symptoms in an ambulant patient may equally, though less commonly, be due to emboli and should arouse suspicion.

SUMMARY

Pulmonary embolism may be the first manifestation of symptomless thrombosis in the leg veins of ambulant persons and in such circumstances may present difficulty in diagnosis. Four illustrative cases are described.

Dr. T. E. Goodier performed the postmortem examinations.

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Annular Pancreas as a Surgical Problem

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Since annular pancreas as an anatomic anomaly was first described by Ecker [15] in 1862, many articles on this subject have appeared in the literature. Compilations of reported cases * have served gradually to build up our knowledge concerning a condition which, so far as can be ascertained, was not diagnosed preoperatively before 1942.[27] Hope and Gibbons [23] stated that 48 cases treated surgically had been reported to July, 1953, and Skapinker [39] in 1954 collected and reviewed 45 such cases. Only when sufficient cases have been reported will a sound basis for the proper therapeutic approach be established.

I have been able to collect 72 surgical cases through 1954 from the available literature, to which 1 case is added here (Tables 1 and 2), and it is believed this number is sufficient for further analysis at this time and tentative evaluation of the various methods of surgical treatment. As this anomaly manifests itself clinically, if at all, either in early infancy or not until adulthood and as the findings in adult and pediatric cases differ substantially, the data compiled here are analyzed separately for each of these two groups. They are fairly evenly divided: 38 adult and 35 pediatric cases.

The first recorded operation for annular pancreas was that of Vidal [47] who, in 1905, described a posterior gastroenterostomy done on a 3-day-old infant for obstruction of the second portion of the duodenum. Even as an incidental finding at operation, however, annular pancreas was seldom recognized until recent years. Of the total recorded operative cases, 68% have appeared in the literature since 1950. It must be concluded that this anomaly is being searched for and recognized with greater frequency. However, as Warren [49] points out,". . . there is no doubt that this condition is occasionally overlooked, not only by roentgenologists but also by surgeons accustomed to meticulous palpation of the abdominal viscera." Only by mobilization of the duodenum and persistent dissection in his third reported case was Warren able to demonstrate an annular

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* References 25, 27, 31, 35, 39, and 42.

TABLE 1.—*Surgical Treatment for Annular Pancreas — Pediatric Cases*

Case No.	Author	Year Reported	Age of Patient	Sex	Type of Operation	Outcome	Comment
1	Vidal [47]	1905	3 days	M	Posterior gastroenterostomy	Cured	Duodenal atresia
2	Glover & Hamann [17]	1910	5 wk.	F	Division of ring	Cured	Subsequent gastroenterostomy for residual obstruction
3	Gross & Chisholm [21]	1944	3 days	F	Duodenojejunostomy	Cured	Malrotation of bowel
4	Berger & Alrich [9]	1949	4 days	F	Partial resection of ring; Heineke-Mikuliez plastic on duodenum	Died	Necropsy not obtained
5	Haden [22]	1950	3½ yr.	M	Division of ring	Cured	.....
6	Ravitch & Woods [36]	1950	3 days	F	Duodenojejunostomy	Cured	Duodenal stenosis
7	Ravitch & Woods [36]	1950	8 days	M	Gastroduodenostomy	Cured	Malrotation of colon; duodenal atresia; portal vein over duodenum
8	Shapiro, Dennik, & Gerrish [37]	1952	4 days	F	Gastroduodenostomy	Cured	Duodenal atresia

TABLE 1.—*Surgical Treatment for Annular Pancreas—Pediatric Cases*—Continued

Case No.	Author	Year Reported	Age of Patient	Sex	Type of Operation	Outcome	Comment
9	Shapiro, Dzurik, & Gerrish [37]	1952	6 days	F	Duodenoduodenostomy	Died	Stenosis of common bile duct and duodenum
10	Shapiro, Dzurik, & Gerrish [37]	1952	17 days	M	Duodenoduodenostomy	Cured	Mongolism; duodenal stenosis
11	Wilson & Bushart [52]	1953	30 days	M	Posterior gastroenterostomy	Cured	.....
12	Wilson & Bushart [52]	1953	20 mo.	M	Duodenojejunostomy	Cured	.....
13	Wilson & Bushart [52]	1953	5 days	M	Duodenojejunostomy	Died (aspiration pneumonia)	Necropsy not obtained
14	Gross [20]	1953	5 mo.	F	Duodenojejunostomy	Died	Ectopic kidney; Meckel's diverticulum; accessory spleen
15	Gross [20]	1953	2 days	F	Duodenojejunostomy	Died	Malrotation
16	Gross [20]	1953	1 day	F	Duodenojejunostomy	Cured	Meckel's diverticulum
17	Gross [20]	1953	5 days	F	Duodenojejunostomy	Cured	.....
18	Gross [20]	1953	5 days	F	Duodenojejunostomy	Cured	Questionable mongolism
19	Gross [20]	1953	1 day	M	Duodenojejunostomy	Died	Esophageal atresia (operated); congenital heart disease
20	Gross [20]	1953	5 days	M	Duodenojejunostomy	Cured	Malrotation (Ladd's operation)
21	Gross [20]	1953	1 day	M	Duodenojejunostomy	Died (heart disease)	Esophageal atresia (operated); imperforate anus (colostomy); congenital heart disease; died at 3 mo.
22	Gross [20]	1953	2 days	M	Duodenojejunostomy	Cured	Questionable mongolism
23	Kiesewetter & Koop [25]	1954	18 days	M	Division of ring	Died	Duodenal stenosis; mongolism; death after secondary gastrojejunostomy
24	Kiesewetter & Koop [25]	1954	4 days	M	Duodenojejunostomy	Died	Severe stenosis of duodenum; aspiration after secondary gastrojejunostomy
25	Kiesewetter & Koop [25]	1954	6 days	F	Gastrojejunostomy	Died	Esophageal atresia with tracheoesophageal fistula (operated)
26	Kiesewetter & Koop [25]	1954	5 days	F	Gastrojejunostomy	Died	Malrotation of colon; atresia of duodenum
27	Kiesewetter & Koop [25]	1954	3 mo.	F	Duodenojejunostomy	Cured	Malrotation of colon; duodenal stenosis; duodenal bands; cured by gastric resection after primary duodenojejunostomy failed
28	Kiesewetter & Koop [25]	1954	3 days	F	Duodenojejunostomy	Cured	.....
29	Small & Berman [40]	1954	2 days	M	Duodenojejunostomy	Cured	.....
30	Hope & Gibbons [23]	1954	14 days	M	Resection of ring; anterior gastrojejunostomy 6 days later	Died	Mongolism; persistent obstruction after resection of ring; duodenal stenosis at level of annular pancreas
31	Hope & Gibbons [23]	1954	5 days	M	Duodenojejunostomy; gastrojejunostomy 7 days later	Died	Persistent obstruction until second operation; duodenal stenosis at level of annular pancreas
32	Hope & Gibbons [23]	1954	6 days	F	Posterior gastroenterostomy and gastrostomy	Died	Tracheoesophageal fistula (operated); annular pancreas found at necropsy
33	Hope & Gibbons [23]	1954	5 days	M	Gastrojejunostomy	Died (aspiration pneumonitis)	Malrotation of colon; duodenal atresia
34	Hope & Gibbons [23]	1954	3 mo.	F	Duodenojejunostomy and section of duodenal band; gastrojejunostomy 3 days later; gastric resection 11 days later	Cured	Persistent obstruction after duodenojejunostomy; jejunal intussusception found after gastrojejunostomy; malrotation of small bowel
35	Hope & Gibbons [23]	1954	7 days	F	Section of duodenal band, 4th portion, and ligament of Treitz; duodenoduodenostomy 5 days later	Cured	Obstruction due to duodenal fibrosis at 4th portion; malrotation of colon; Sprengel's deformity; agenesis right lung; deformity of thoracic and cervical spine

TABLE 2.—*Surgical Treatment for Annular Pancreas—Adult Cases*

Case No.	Author	Year Reported	Age of Patient, Yr.	Sex	Type of Operation	Outcome	Comment
1	Dos Santos [14]	1906	26	F	Posterior gastroenterostomy	Died (pneumonia)	Chronic interstitial pancreatitis; peptic ulcer
2	Lerat [28]	1910	46	F	Division of ring	Cured	Chronic pancreatitis; drainage ceased 13th day
3	Smetana [41]	1928	74	M	Posterior gastroenterostomy	Died	Marked fibrosis of pancreas; peptic ulcer; cystic duct cancer
4	Howard [24]	1930	46	F	Division of ring	Cured	Fistula developed requiring second operation
5	Brines [6]	1930	35	M	Drainage (for pancreatitis)	Died	Annular pancreas found at necropsy
6	Zech [53]	1931	27	F	Division of ring; Heineke-Mikulicz plastic on duodenum	Cured	Pancreatic fistula
7	Brines [7]	1931	44	M	Posterior gastroenterostomy	Died	Respiratory infection; peptic ulcer
8	Truelsen [46]	1940	35	M	Posterior gastroenterostomy; plastic on duodenum	Cured	.....
9	Lehman [27]	1942	23	M	Division of ring	Recovered (persistent symptoms)	Chronic interstitial pancreatitis; persistent deformity of duodenum (postoperative x-ray)
10	Custer & Waugh [13]	1944	74	M	Partial gastrectomy	Cured	Concomitant gastric ulcer
11	Goldyne & Carlson [9]	1946	26	M	Division of ring	Recovered (persistent symptoms 6 yr. later)	Persistent deformity of duodenum (postoperative x-ray)
12	Nedelec [32]	1946	17	M	Gastroenterostomy	Cured	.....
13	Brown, Bingham, & Cronk [8]	1948	53	F	Resection of ring	Died	Duodenal fistula; G. I. tract bleeding before surgery; secondary gastrojejunostomy
14	Ohlmacher & Marshall [33]	1950	27	M	Partial gastrectomy; gastrojejunostomy	Cured	Chronic gastritis and duodenitis with antral deformity
15	Baker & Wilhelm [2]	1950	59	M	Partial gastrectomy; gastrojejunostomy	Cured	Concomitant gastric ulcer
16	Ravitch & Woods [36]	1950	57	M	Partial resection of ring; duodenojejunostomy on following day	Cured	Normal pancreas at operation; postoperative local pancreatitis resulting in obstructive scar formation
17	Conroy & Woelfel [11]	1951	26	F	Gastroenterostomy	Cured	.....
18	Conroy & Woelfel [11]	1951	30	M	Division of ring; excision of redundant duodenal wall	Cured	Healed duodenal ulcer on anterior duodenal wall
19	Bickford & Williamson [4]	1951	25	M	Gastroenterostomy	Cured	.....
20	Cattell †	1951	52	M	Division of ring; gastric resection	Cured	Concomitant duodenal ulcer; postoperative pancreatic and duodenal fistulas (Roux exclusion excision of fistulas)
21	Payne [35]	1951	33	M	Partial resection of ring	Recovered (persistent duodenal obstruction)	Microscopically normal pancreas; massive G. I. tract hemorrhage 5 yr. prior to surgery
22	Anderson & Wapshaw [1]	1951	32	F	Resection of ring	Cured	Concomitant jaundice due to distal biliary obstruction caused by pancreatitis
23	Wakely [48]	1951	36	M	Resection of ring	Cured	Microscopically normal pancreas; symptom-free on 10-yr. follow-up
24	Silvis [38]	1952	37	M	Partial resection of ring	Cured	Chronic pancreatitis on microscopic section; pancreatic fistula developed
25	Bovill & Bailey [5]	1952	26	M	Gastric resection	Cured	Duodenal stenosis
26	Tomsykoski, Stevens, & Izzo [45]	1953	50	F	Gastric resection and division of ring	Cured	.....
27	Warren [49]	1952	22	F	Cholecystectomy and choledochostomy; excision of pyloric antrum and first portion of duodenum	Recovered (persistent symptoms)	Previous gastrojejunostomy with resection of pyloric antrum (annular pancreas found at this operation by mobilizing duodenum)
28	Warren [49]	1952	41	F	Gastroenterostomy; vagotomy; choledochostomy	Cured	Evidence of anterior wall duodenal ulcer; postoperative diarrhea for 10 days

TABLE 2.—*Surgical Treatment for Annular Pancreas—Adult Cases*—Continued

Case No.	Author	Year Reported	Age of Patient, Yr.	Sex	Type of Operation	Outcome	Comment
29	Castleton, Morris, & Kukral [10]	1953	41	M	Gastroenterostomy; choledochostomy	Cured	Concomitant acute pancreatitis, amebiasis, ulcerative colitis
30	Goldyne & Carlson [19]	1953	54	F	Resection of ring; resection of duodenal bands	Recovered (persistent duodenal obstruction)	Massive gastric hemorrhage from peptic ulcer 2 yr. postoperatively
31	Gonzales, Lopez, & Paz ‡	1952	25	F	Cholecystectomy; second operation: sectioning of pancreatic ring	Cured	Annular pancreas missed at first operation
32	MacPhee [29]	1953	26	M	Resection of ring	Recovered	Recurrence of obstructive symptoms 6 yr. postoperatively, with x-ray evidence of constriction of operative site
33	Swynnerton & Tanner [43]	1953	30	M	Subhiatal vagotomy; Heineke-Mikulicz pyloroplasty	Cured	Concomitant duodenal ulcer; annular pancreas found incidentally; no constriction
34	McGee, Black, & Beattie [30]	1953	62	M	Posterior gastroenterostomy	Cured	.....
35	Gillette & Lynch [16]	1954	64	M	Duodenojejunostomy	Cured	Chronic pancreatitis
36	Skapinker [39]	1954	22	F	Duodenojejunostomy	Cured	6-mo. follow-up
37	Hope & Gibbons [23]	1954	54	M	Resection of ring; resection of ring and duodenojejunostomy 5 mo. later	Cured	Pseudocyst formation after first operation; microscopically normal pancreas
38	Sanford	1954	38	M	Gastric resection and tube duodenostomy	Cured	Concomitant acute pancreatitis, acute duodenitis and periduodenitis; 1-yr. follow-up

* References 18 and 19.
† In discussion on Payne.[35]
‡ Cited by Skapinker.[39]

pancreas as the real pathologic problem. It is significant that this had been the patient's third operation for upper gastrointestinal complaints of 21 years' duration.

The case reported here was also most elusive because of pancreatic, duodenal, and periduodenal inflammation, even though a preoperative diagnosis of annular pancreas and a careful search for the specific lesion had been made. The diagnosis has rarely been made preoperatively. The present case is the ninth in which such a diagnosis was made—only 12% of all the cases with clinical manifestations.

EMBRYOLOGY

The embryologic development of an annular pancreas has been widely discussed.† Briefly, there are three main concepts: those of Lecco,[26] Baldwin,[3] and Weissberg.[50] Most authorities agree up to the point of rotation of the duodenum with its associated pancreatic anlagen.

The pancreas is derived from two main primordia: the dorsal and the ventral buds. The dorsal bud is an outpouching of entoderm from the dorsal portion of the duodenum. In its growth it pushes between the leaves of the splanchnic mesoderm, the dorsal mesentery. The large portion of the distal main pancreatic duct (the duct of Wirsung), which develops within the tail, body, and most of the head of the pancreas, is formed from the dorsal bud. The ventral bud may be paired into a left and a right bud. Theoretically, the ventral left bud atrophies while the right one, which contains the developing terminal or duodenal portion of the duct of Wirsung, rotates clockwise with unequal growth and rotation of the duodenum, first posteriorly, then medially, and finally inferiorly, to form the inferior portion of the head of the pancreas.[34]

The disagreement between Lecco and Baldwin concerning the formation of annular pancreas is based upon whether or not the left ventral bud atrophies. Lecco believes that it does and postulates that the right ventral anlage remains adherent at its tip, and when migration of its base occurs the duodenum becomes encircled in a ring of

† References 3, 26, 31, 44, and 50.

pancreatic tissue. Baldwin believes that the left ventral anlage persists and develops, thus completing the circle of pancreatic tissue about the duodenum. Tieken [44] in 1901 postulated a hypertrophy of both the ventral and the dorsal anlagen joining to encircle the duodenum.

The concept of Lecco is generally accepted. However, Weissberg [50] found an annular pancreas in a 16-mm. embryo calculated to be in approximately the sixth or seventh week of development. The anterior ring appeared to originate from the ventral anlage that had expanded about the duodenum. The ring was well formed, and he theorized that there may be an unusual growth of one of the ducts of the pancreas which the local mechanical situation may direct into the anomalous position.

DIAGNOSIS

In order to discuss diagnosis one must specify the age of the patient. Characteristically the patient becomes a clinical problem very early in life, in adulthood, or not at all. This wide spread in age incidence, together with the large number of patients in whom an annular pancreas was found at necropsy but had caused no difficulties during life, in many instances a long life, is difficult to explain. This problem will be discussed further.

Pediatric Cases.—The pediatric patients reported as treated surgically, with only six exceptions, have been in severe enough difficulty to be subjected to operation within the first three weeks of the neonatal period, most of them within the first week. The ages ranged from 1 day to 3½ years. The diagnosis of high-intestinal obstruction was made because of persistent emesis of most or all ingested food, and operation was undertaken to relieve this obstruction with the expectancy of finding the obstruction at the duodenum on the basis of pyloric stenosis, atresia, congenital mesenteric band, or traumatic ileus. The radiologist in two instances reported by Kiesewetter and Koop [25] suggested that "the appearance is not unlike previous cases of annular pancreas seen at this clinic." This points up the value of previous experience and interest in the lesion as a possible cause of neonatal high-intestinal obstruction.

Roentgenograms of the abdomen, together with an upper gastrointestinal tract series, may give the only definite clue to the correct diagnosis. The finding of the so-called "double-bubble" sign, signifying gas in the dilated stomach and first portion of the duodenum and no gas in the remainder of the abdomen (as seen on plain films), together with the finding of midduodenal notching or constriction at the ampullary portion of the second part of the duodenum with delayed emptying (as seen after ingestion of a contrast medium), is highly suggestive of annular pancreas. If there is atresia of the duodenum, total obstruction is demonstrated by roentgenographic examination; however annular pancreas must still be ruled out at operation.‡

Blockage of the common bile duct may, in rare instances, cause jaundice to be the presenting sign. Inflammatory or developmental compression of the distal common bile duct in association with annular pancreas has been reported.

Adult Cases.—In the cases reported in the literature the adult patients have ranged in age from 17 to 74 years, with a mean age of 39 years. Why a patient having an annular pancreas that was present from birth may for some 40 years escape complications severe enough to warrant surgical intervention is still somewhat obscure. Indeed, many cases reported as incidental findings at necropsy were merely anatomic oddities, the anomaly having caused no real difficulty during the life of the patient.

It has been suggested that recurrent attacks of mild pancreatitis may cause progressive constriction of the ring. The anomalous duct system in the annulus would seem to lend itself to altered pressures and regurgitation, thus rendering the pancreas vulnerable, by stasis and infection, to subsequent inflammation. Lehman [27] noted that in 5 of 10 cases which he summarized pancreatitis was a complication. In the present review 10

‡ References 25, 36, 37, and 47.

cases were reported in which the author definitely stated that pancreatitis had been found. In three instances it was also stated that on microscopic examination the resected portion of pancreas was found to be normal.§ Although much information is lacking, it would seem that at present there is some basis for concluding that pancreatitis within the annulus is often a large factor in the production of symptoms.

Other pathologic conditions also must be accepted as etiologic agents in the production of symptoms (Table 5), and among these peptic ulcer seems most important. Peptic ulceration at some stage was noted in 13, or 34%, of the 38 adult cases summarized in this study. Goldyne and Carlson [19] postulate that the ulcer is caused by attenuation of the wall due to obstruction, with subsequent ischemia, necrosis, and fibrosis. This theory was also proposed by Truelsen.[46] Lehman [27] suggested that peptic ulcer was possibly the result of disturbed acid-base relationships at the pylorus. It seems reasonable that any degree of chronic duodenal obstruction above the ampulla would rob the ulcer-prone area of the duodenum and stomach of the normal neutralizing fluids from the liver and pancreas. Adding this situation to the stresses that the mucosa and walls of these organs are subjected to by chronic obstruction, it would not seem amiss to conclude that peptic ulceration might ensue.

The preoperative diagnosis in adult patients has been reported only eight times in the literature. It was entertained by considering the history, clinical observations, and roentgenographic findings together.

In the history, pain, gaseous eructation, bloating, and vomiting have been the cardinal symptoms. The pain has been reported as varying from postprandial discomfort to rhythmic, severe epigastric pain of a crescendo nature often relieved only by vomiting. The ulcer type of pain (epigastric burning referred to the back and relieved by alkali ingestion) has been noted frequently; in fact, the clinical diagnosis most usually made has been peptic ucer in some stage of its development or complications. Anderson and Wapshaw [1] reported one patient with a history of jaundice as the presenting complaint. They found the annulus to be acutely inflamed and believed that this caused compression of the distal common bile duct, resulting in obstructive jaundice.

In no instance has the physical examination contributed to the final diagnosis.

Roentgenographic study by upper gastrointestinal tract series is the most fruitful part of the clinical examination. It is this examination that crystallizes the presumptive diagnosis. Typically a partial block with dilatation of the first portion of the duodenum is seen. The midportion of the second part of the duodenum is notched or constricted by extraluminal pressure, and a delay in emptying of the stomach and first portion of the duodenum is noted. In some cases tremendous dilatation of the first portion of the duodenum has been reported; in others the results of scarring by peptic ulceration have revealed a "ragged, irregular" duodenal bulb with subsequent stenosis, thus rendering the chance of correct diagnosis more remote.

Erroneous diagnoses of cicatrizing peptic ulcer, duodenal ulcer, duodenal diverticulum, congenital duodenal band, primary neoplasm of the duodenum, arteriomesenteric ileus, cholecystitis, and choledocholithiasis have been made.

In brief, a history of upper gastrointestinal complaints, obstructive symptoms and signs, and highly suggestive roentgenographic findings, together with a healthy suspicion on the part of the clinician, should increase the number of correct preoperative diagnoses. It should be stressed again that annular pancreas must be searched for at operation; to this end rotation of the duodenum by the Kocher maneuver is usually necessary.

REPORT OF A CASE

A 38-year-old white salesman was admitted to the Millard Fillmore Hospital on Jan. 11, 1954, with the chief complaints of epigastric pain and vomiting for four days.

§ References 35, 36, and 48.

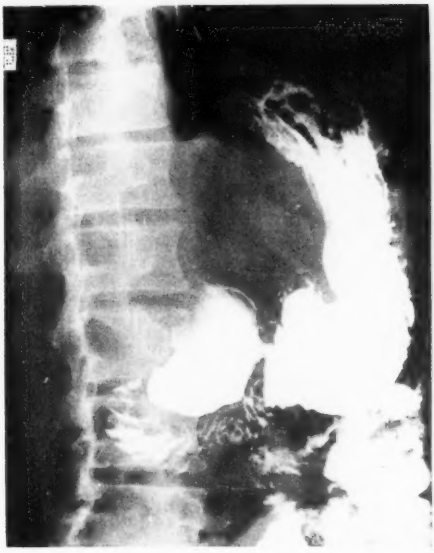


Fig. 1.—Film taken June 20, 1953, showed dilated duodenal bulb with postbulbar constriction and normal duodenal mucosa beyond the constriction.

He had been seen by Dr. Henry N. Kenwell, chief of the surgical service, one year prior to this admission, at which time he complained of epigastric crampy, burning pain "boring through to the back" and occasional emesis. Upper gastrointestinal tract roentgenographic studies were made at that time, and the diagnosis of annular pancreas was made by Dr. Kenwell (Figs. 1 and 2). The patient refused surgical treatment.

The patient was again seen six months later, and further roentgenographic studies were made. The roentgenologist reported "ballooning of the duodenal cap and delay in the passage of barium into the second portion of the duodenum." The patient again refused operation and was treated medically on an ulcer regimen. He continued to have periodic attacks of epigastric burning and crampy-type pain associated with postprandial emesis lasting one to two days. He noted some improvement on intensive ulcer therapy; however, during the week prior to admission the pain became much severer than it had ever been and was associated with intractable emesis. He reported a weight loss of 22 lb. in the previous year.

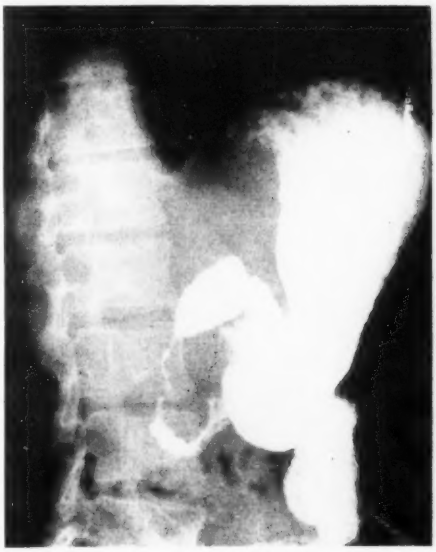
The patient was well developed and appeared dehydrated and acutely ill. The tongue was coated and moderately dry. The heart rate was 108 beats per minute. The chest was clear, and the blood pressure was 116 mm. Hg systolic and 80 diastolic. The abdomen was tense, with associated spasm and tenderness to deep palpation in the right upper quadrant. There was no appreciable distention, and peristalsis was normally active.

The erythrocytes numbered 6,000,000 and the leucocytes 16,700 per cubic millimeter of blood, with a differential count of 74% filaments, 10% band forms, 5% intermediate lymphocytes, 2% small lymphocytes, 7% monocytes, 1% basophiles, and 1% eosinophiles. The hemoglobin content of the blood was 17.85 gm. per 100 cc., or 123%. The urine specific gravity was 1.022, the reaction for albumin 1+, the blood sugar 123 mg. per 100 cc., and the urea nitrogen 66 mg. per 100 cc. (interpreted as being due to dehydration).

The patient was given intravenous fluids and supportive therapy, and on Jan. 15 operation was performed. Through an upper midline incision the abdominal cavity was explored. The first portion of the duodenum was markedly dilated in all directions to a diameter of 3.5 in. The foramen of Winslow was obliterated; the gall bladder was thickened and edematous; the head of the pancreas was enlarged to the size of a fist, and the body and tail of the pancreas were uniformly hard but not enlarged.

A constriction felt at the second portion of the duodenum by extraluminal exploration was confirmed by duodenotomy. The constricting area was carefully explored, and the pancreatic annulus was found and noted to be involved in acute inflammation. No evidence of hemorrhagic necrosis could be found. The Kocher maneuver to facilitate further exploration of the area was not done because of the

Fig. 2.—Film taken Jan. 6, 1954, showed moderately dilated duodenal bulb and definite area of constriction in postbulbar portion of the duodenum.



extensive inflammation of the entire area. The proximal duodenal segment was thick, fibrous, and very inflamed. The pyloric area was attenuated and identified only by the pyloric vein.

The duodenum was transected about 1.5 cm. beyond the pyloric vein, and, since it was impossible adequately to "turn in" the duodenal stump, catheter duodenostomy as described by Welch [51] was done. An 80% gastric resection of the antecolic loop, Hofmeister type, was then accomplished with no difficulty.

The postoperative course was uneventful. The duodenostomy tube posed no problems and was removed on the 12th postoperative day. The patient was discharged on the 21st postoperative day, ambulatory and with no complaints. He has remained asymptomatic to the present.

Pathologic examination showed evidence of hemorrhagic duodenitis in the excised specimen.

Comment.—The difficulty of demonstrating an annular pancreas when the area is acutely inflamed is exemplified by this case. Only careful dissection and ultimate duodenotomy revealed the true nature of the pathologic lesion, even when the cause was strongly suspected and being sought.

TREATMENT AND RESULTS

Surgery has been the only method advocated for treatment of the patient with symptomatic annular pancreas. The procedures have varied, and justifications have been offered for each method. The operative treatment offers a choice of direct attack upon the annulus, a bypassing procedure, a combination of direct attack and plastic procedure on the duodenum, or a combination of the bypassing procedure and direct attack on the ring.

Pediatric Cases.—Thirty-five pediatric cases in which operation was done were found in the literature (Tables 1 and 3). There were 15 deaths, a case fatality rate of 43%; however, 1 of these 15 should be excluded, as death occurred three months later.[20] Resection of the ring was done in five instances; three of these patients died, and three required a secondary bypassing procedure to relieve persistent obstruction. No fistulas have been reported, but, as is pointed out later, this danger is quite real.

Bypassing procedures were done in the remaining 30 pediatric cases. Duodenojejunostomy was the operation most frequently done. Nine patients were reported as cured, and four required subsequent gastric resection or gastroenterostomy to relieve persistent obstruction.[25] Duodenojejunostomy is now the method of choice of pediatric surgeons with the most extensive experience.‖ This operation was first used by Gross and Chisholm,[21] who, in 1944, advocated this type of correction because it relieves the duodenal stasis, does not interfere with gastric function, and eliminates the hazards attendant on cutting the pancreatic ring. They recommend isoperistaltic duodenojejunostomy for all cases.

Gastroenterostomy has its proponents but, as has been pointed out,[20] may not effectively drain the proximal portion of the duodenum. Six gastroenterostomies were performed on pediatric patients, with four deaths and two cures. Two duodenoduodenostomies were

TABLE 3.—*Results of Operation for Annular Pancreas—Pediatric Cases*

No. of Patients*	Primary Operation	Cured After Primary Operation	Recovered	Reoperated	Complications: Pancreatic Fistula	Complications: Persistent Symptoms	Died
5	Section of annulus	2	..	3	..	2	3
6	Gastroenterostomy	2	..	..	..	..	4
2	Duodenoduodenostomy	1	..	..	..	..	1
2	Gastroduodenostomy	2	..	..	..	..	..
19	Duodenojejunostomy	9 (47%)	3 (16%)	4 (21%)	..	3 (16%)	7 (37%)
1	Section of duodenal band	..	1	1	..	1	..
Total 35		16 (46%)	4 (11%)	8 (23%)	0 ..	6 (17%)	15 (43%)

* Of the total patients, 18, or 51%, were girls.

‖ References 20, 21, and 25.

done, with one death and one cure. Two gastroduodenostomies were done, with two cures. It will be extremely interesting to learn whether or not marginal ulceration becomes a problem when these children reach adulthood.

Associated anomalies would seem to worsen the prognosis. Most of the patients who died subsequent to alleviation of their obstruction had other anomalies which certainly lessened their chances for survival. Twenty-six, or 74%, of the pediatric patients had associated anomalies (Table 6).

Adult Cases.—Thirty-eight adults, including my patient, have had operative treatment (Tables 2 and 4). There were five deaths, a case fatality rate of 13%. Twenty-five, or 66%, were males and 13, or 34%, were females. This ratio is in general agreement with previous reports. (It is interesting, however, to note that among the pediatric cases reported the females show slight predominance in numbers—18, or 51%, females to 17, or 49%, males.)

Section of the annulus was carried out in 15 of the adult patients. Nine, or 60%, were cured; four, or 27%, required subsequent operation to relieve the obstruction; in four, or 27%, a pancreatic fistula developed, and five, or 33%, complained of persistent symptoms.

These results are considered poor when compared with those of other procedures available. It is evident that pancreatic fistula is a definite hazard, even in the hands of a competent operator who may understand the anomalous duct system [12] and who resects anteromedially into the ring. Most distressing has been the lack of alleviation of symptoms and the need, in both adult and pediatric patients, for another surgical procedure to bypass the obstruction which remains in many cases. The authors who have discussed this problem to any extent are in general agreement that the annulus should be avoided. Exceptions to this opinion have been voiced rarely.

Gastroenterostomy was performed as a primary procedure in 10 adult patients (Table 3). Seven, or 70%, were cured; one patient required reoperation, at which time the pyloric antrum and first portion of the duodenum were excised (Case 27, Table 2), and there were three deaths. It must be noted, however, that all these patients died before the era of antibiotics and modern methods of anesthesia and supportive therapy. The results of gastroenterostomy show improvement over those of resection of the annulus, but the problem of proximal loop stasis must be considered. None of the patients had a concomitant vagotomy.

Two patients were treated by gastric resection and division of the annulus. Both were reported as cured, but the severe complication of fistula developed in Cattell's

TABLE 4.—*Results of Operation for Annular Pancreas—Adult Cases*

No. of Patients*	Primary Operation	Cured After Primary Operation	Recovered	Reoperated	Complications: Pancreatic Fistula	Complications: Persistent Symptoms	Died
15	Section of annulus	9 (60%)	5 (33%)	4 (27%)	4 (27%)	5 (33%)	1 (7%)
10	Gastroenterostomy	7 (70%)	..	..	..	1	3 (30%)
5	Gastric resection	5	..	..	..	..	..
2	Gastric resection and division of ring	2	..	1	1	..	..
2	Duodenojejunostomy	2	..	..	..	..	..
1	Drainage for pancreatitis	..	..	..	..	..	1
1	Vagotomy and pyloroplasty	1	..	..	..	1	..
1	Cholecystectomy and secondary section of annulus	1	..	1	..	..	..
1	Gastrojejunostomy with section of pyloric antrum	..	1	1	..	..	..
		—	—	—	—	—	—
Total 38		27 (71%)	6 (16%)	7 (18%)	5 (13%)	7 (18%)	5 (13%)

* Of the total patients, 25, or 66%, were male.

case,¶ requiring reoperation. This again points out the danger of cutting the ring.

Duodenojejunostomy was done in only two patients, with resultant cure. Many authors are enthusiastic about this procedure in adults. I do not share this enthusiasm because of the danger of subsequent marginal ulceration.

Five patients were treated by gastric resection with five or 100%, resulting cures. No complications have been reported. Certainly this is too small a number of cases from which to draw a definite conclusion at this time, but they do show consecutively good results.

TABLE 5.—*Associated Lesions in Adult Cases*

Type of Lesion	No. of Cases	Per Cent of Total Cases
Peptic ulcer	13	34
Gastritis and/or duodenitis	2	5
Pancreatitis	10	26
Jaundice with biliary obstruction	1	3

TABLE 6.—*Associated Anomalies in Pediatric Cases*

Type of Associated Anomaly	No. of Cases	Per Cent of Total Cases
Gastrointestinal	21	60
Respiratory and gastrointestinal	5	14
Cardiovascular	4	11
Mongolism	4	11
Involvement of multiple systems	10	29

The high incidence of peptic ulcer in the adult, 34% (Table 5), noted at the time of operation or after inadequate surgical treatment, cannot be overlooked. Also, in reviewing the histories of the reported cases, peptic ulceration must be included as a concomitant pathologic process,# even when it has occurred some years prior to the operation for correction of the obstructive symptoms. Many of these patients had had complaints referable to the upper gastrointestinal tract, in some instances for as long as 22 years. The danger of recurrent peptic ulceration in any other bypassing procedure that does not attempt to remove the acid-producing portion of the stomach must be considered. Goldyne and Carlson[19] in their second paper stressed this hazard and cited two cases: One patient who had been reported as cured six years after resection of the annulus complained of persistent symptoms and was shown on roentgenographic examination to have a duodenal ulcer. The other, two years after resection of the annulus, had massive hematemesis caused by a gastric ulcer.

Chronic and acute gastroduodenitis were reported in two instances.

Considering the good results in the reported cases and the over-all low fatality rate and good results of adequate subtotal gastric resection in general, this procedure would seem justified as a method of bypassing the obstructing lesion and insuring the patient against further difficulty.

There are those who suggest that sectioning the ring in conjunction with a bypassing procedure may prevent further attacks of pancreatitis and, in cases of gastrectomy, help to keep the proximal duodenal stump decompressed. There is no evidence at this time that resection of the ring will prevent initial or recurrent pancreatitis in the annulus. There will be no necessity for decompression of the duodenal stump if the proximal duodenum is resected and turned in at the superior margin of the annulus. If severe inflammation and edema are present, rendering it unwise or unsafe to close the duodenal stump, a tube duodenostomy will solve the problem.

There will be those proponents of gastroenterostomy with vagotomy who may suggest this method of treatment of annular pancreas. No issue is taken with them, as there are no reported cases in which this procedure was utilized.

SUMMARY AND CONCLUSIONS

The available literature is reviewed through 1954, and 72 cases of annular pancreas treated by operation are collected, to which 1 such case is added.

As the symptomatology, diagnosis, and treatment in adult and pediatric patients differ, the total cases are divided into these two groups and separately analyzed.

¶ Cattell, R. B., in discussion on Payne.[35]

References 19, 35, and 49.

Duodenojejunostomy is advocated at present as the treatment of choice in pediatric cases.

Adequate subtotal gastric resection is advocated as the treatment of choice in adult cases because of the high incidence of concomitant peptic ulcer and as an effective method of bypassing the obstruction.

The anomaly is being recognized ante mortem with greater frequency.

The preoperative diagnosis of annular pancreas is rare, having been reported only eight times. The diagnosis was made preoperatively in the case presented here.

Increasing awareness of this condition by radiologists will undoubtedly lead to its preoperative diagnosis in many more instances.

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Phrenic Nerve Traction for Persistent Hiccough (Singultus)

A Preliminary Report

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The treatment of persistent hiccough is at times extremely difficult. Several methods, including direct pressure, carbon dioxide inhalations, sedatives, and electro-phrenic stimulation, have been used with varying degrees of success. There are those cases, however, in which the usual methods fail.

In the past four years phrenic-nerve traction has been used successfully where other methods have failed. One patient required bilateral phrenic traction.

Fluoroscopy is used to determine which portion of the diaphragm is involved. Phrenic-nerve traction is accomplished by exposing the nerve in the neck (with use of local procaine hydrochloride [Novocain] anesthesia) through a 4 cm. incision located 3 cm. above and parallel to the clavicle, beginning just lateral to the midline anteriorly.

The incision is carried down through the skin, superficial fascia, and platysma, exposing the sternocleidomastoid muscle. The sternocleidomastoid is retracted anteriorly, exposing the scalenus anticus muscle upon which is found the phrenic nerve passing obliquely downward across the muscle. Care is taken to avoid damaging the external jugular vein.

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A No. 34 or 36 stainless steel wire is then passed beneath and around the phrenic nerve to form a loop extending out beyond the skin edges. The wound is then closed with interrupted fine 0000 nonabsorbable surgical (silk) sutures. The ends of the wire loop are tied. A sterile dressing can be applied to the wound in such a way that traction can be applied as long as it is necessary to control the paroxysm.

The nurse, intern, and resident can be instructed in this maneuver. The patient can, likewise, be instructed to apply gentle traction.

The wire is left in situ as long as hiccough persists. When it is controlled, one side of the loop can be cut at the skin edge for removal of the wire.

This procedure has been carried out on four patients since 1952, without failure. One patient had bilateral phrenic traction.

COMMENT

Hiccough [1] is a respiratory reflex which consists of several short contractions of the diaphragm, usually unilateral. Persistent hiccough may be due to several causes. In some cases the cause is obscure. Epidemic hiccough (Abraham's) is supposed to represent an abortive type of encephalitis. Its occurrence was first noted in 1919, in Egypt. Other epidemics have been observed in Austria, Germany, and Canada. In 1930 there were said to have been 5000 cases in Paris. In the same year there were several cases in England, Switzerland, and a few in the United States. In 1924 there were doz-

ens of cases seen in England and America. The disease is confined to the colder months, usually the fall, and affects middle-aged men. It rarely occurs in childhood. The disease may last from one to 7 days.

Persistent hiccough is sometimes seen following intra-abdominal surgery. In this instance the frequency and persistence may become extremely serious even to the point of debility.

The phrenic is a mixed nerve * which arises from either C-3 and C-4 segments or C-4 and C-5 segments of the spinal cord. The major supply is from C-4. It receives a branch from the subclavian nerve (C-5) and has three branches, the ramus pericardiacus, pleural, and diaphragmatic. It also anastomoses with the phrenic plexus of the sympathetics of the liver and adrenals.

* References 2 and 3.

The afferent stimuli [4] seem to arise from the lungs, pleura, and diaphragm and are carried by afferent fibers in the phrenic to the respiratory center. The efferent distribution has already been described. Direct stimulation, therefore, of the phrenic nerve by traction interrupts not only the afferent but also the efferent fibers.

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A Minor Operation for the Permanent Relief of Tic Douloureux

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This article describes a relatively simple surgical procedure which was devised to give permanent relief to patients with tic douloureux and at the same time to avoid producing the extensive area of anesthesia which results from sectioning the sensory root of the fifth cranial nerve. It has been used in a number of severe cases, with complete success in each case, and is reported as an additional aid in the treatment of this painful condition.

While it is true that trigeminal neuralgia may be caused by irritative or progressive lesions deep in the face or in the central nervous system, in most cases the disease is peripheral. A trigger zone of hyperirritability develops in one or more of the terminal branches of the nerve, and it is the stimulation of these nerve endings which induces the paroxysms. The trigger area becomes so abnormally excitable that any slight stimulus, such as talking, chewing, or even a light touch, will set off a discharge of lancinating pain throughout the distribution of the branch involved. The essential factor in preventing this discharge is the interruption of the pain impulses from the trigger zone.

Alcohol injections into the nerve trunk have been used to destroy the axons and produce anesthesia. These injections are usually temporary in effect, are difficult to place accurately, and are not without pain and complications in themselves.

Cutting the sensory root of the semilunar ganglion is effective in permanently stopping the pain, but it has such serious disadvantages that a less heroic treatment, if effective, would be preferred. The root operation requires the skill of a neurosurgeon and entails the hazards and possible complications of brain surgery. In destroying the entire fifth nerve a tremendous loss of sensation results, with accompanying trophic changes and paresthesia. The anesthesia involves the entire front one-fourth of the head, internally and externally, from the scalp to the chin, and includes one-half of the face, the eye, the nasal passage, the anterior two-thirds of the tongue, and much of the oral cavity. The anesthesia of the cornea predisposes to unrecognized injuries and ulcers.

One needs only to recall the unpleasant paresthesia associated with a dental nerve block of a small segment of this area to appreciate the psychic impact of the permanent loss of sensation over this large area. In fact, many patients, after they have forgotten how severe their suffering was prior to the root section, are critical of the surgeon for having produced such a result. Permanently destroying all sensation over the entire distribution of the fifth nerve to relieve pain in one of its peripheral branches is somewhat analogous to firemen flooding every room in the house with water to put out a fire in the basement.

Before proceeding to any surgery on the nerve branches, one should make a careful differential diagnosis to eliminate the possibility of deep-seated pathology. Many cases are caused by dental caries and residual tooth roots, even in patients wearing full dentures. Also, progress in medical treatment may render surgery unnecessary in some cases.

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In the technique reported here, the surgical attack is pinpointed exclusively to the nerve branch involved in producing the tic. This operation is relatively easy to do and does not require neurosurgical experience. The risks of entering the calvarium are avoided, and hospitalization is brief. The chief shortcoming of the procedure is that it can be used only in cases involving the maxillary and/or the mandibular branches. The anatomical course of the ophthalmic branch does not seem to present a situation where the regeneration of the nerve fibers can be stopped.

Both the maxillary and the mandibular branches of the fifth nerve travel through bony canals, from which they emerge to make their peripheral sensory distributions. Portions of these canals are readily accessible to surgery and can be exposed for the purpose of sectioning the nerve trunk. Regrowth of the cut fibers can be prevented permanently by occluding a short segment of the bony canal with dental amalgam. Thus, if either or both of these nerves are involved in the production of the tic, the trigger area can be rendered permanently anesthetic without destroying the function of any of the innocent branches.

The maxillary nerve, the one most commonly involved in tic, traverses the infraorbital canal, to emerge from its foramen just below the center of the lower rim of the orbit. It supplies sensory fibers to the lower eyelid, the cheek, the lateral surface of the nose, the skin of the upper lip, and the mucous membranes of the upper lip and the anterior gingival surfaces.

The operation to section this branch and to plug its canal is carried out through a mucous membrane incision under the upper lip, similar to that used in exposing the canine fossa for a radical maxillary sinus operation. An external skin incision is unnecessarily disfiguring and has no advantage over the retrolabial approach.

Either general or local anesthesia may be used. I have used local anesthesia in all of my cases. With a long small-bore needle, procaine hydrochloride-epinephrine (Adrenalin) with hyaluronidase is injected under the upper lip, above the canine tooth. The infiltration is carried subcutaneously up to the lower rim of the orbit to block the nerve and then medially and laterally into the tissues of the cheek to give anesthesia for the retraction necessary to expose the foramen. An incision through the mucous membrane, extending about 3 cm. backward from the canine tooth along the fornix of the buccal-gingival fold, is carried through the deeper tissues down to the periosteum. The latter is incised and the bone exposed. The periosteum is elevated along with the overlying tissues until the foramen with the emerging nerve is seen just under the orbital rim. Strong upward retraction is necessary to gain adequate exposure.

When the nerve is well visualized, it is cut so as to leave a short stump protruding from the foramen. It is important that all fibers be severed. A further injection of procaine into the canal is advisable at this point. The stump is grasped with a fine hemostat—close to the foramen—and the fibers are twisted from the canal as deeply as possible. Additional canal contents are removed until there is an empty cavity for a depth of 3 or 4 mm. The bleeding is controlled by pressure with a cotton applicator inserted into the opening. The cavity should be dry before proceeding.

A small amount of dental amalgam is now prepared and tamped firmly into the cavity until the latter is tightly filled flush with the bony surface. The instruments used by dentists in making amalgam fillings are excellent for packing and smoothing the metal. After the canal is securely filled and excess metal scraps are removed, the tissues are replaced and the mucous membrane is closed with interrupted black nonabsorbable surgical (silk) sutures. A pressure bandage is applied over the cheek for a few hours to reduce postoperative oozing and edema. The patient should be warned against unknowingly burning the anesthetized area with hot foods or liquids. An upper denture should not be worn until the edema of the gingiva has subsided.

The mandibular nerve enters its canal on the medial surface of the ramus and, as the inferior dental nerve, runs obliquely downward and forward and then horizontally forward in the body of the mandible, about midway between the lower and the upper border. It supplies the skin over the lower jaw and the corresponding mucous membrane within the mouth as well as the lower teeth. It emerges at the mental foramen, below the second bicuspid. Distally from here it becomes the mental nerve and supplies the skin of the chin, lower lip, and the mucous membrane within the mouth in that area.

The mandibular canal is reached through a skin incision beginning just in front of the anterior border of the masseter muscle. The incision extends forward about 2.5 cm. and is carried directly inward through the periosteum to the surface of the bone. The canal will be found about 1 to 1.5 cm. above the lower border. A hole is drilled into the bone until the canal is opened and the nerve seen running within it. The fibers are cut and removed for a length of 6 or 8 mm. When the oozing is controlled, amalgam is tamped firmly against the medial wall of the canal and into the proximal canal aperture. The entire defect should be filled. After the metal is smoothed flush with the surface of the mandible and the loose scrapings removed, the incision is closed.

The mental foramen is easily reached by incising the mucous membrane and deeper tissues horizontally on the lateral surface of the mandible below the second bicuspid. When the bone is exposed on incising the periosteum, the latter is undermined and retracted downward to the foramen, where the nerve emerges. The nerve fibers are cut and the trunk removed from the foramen as deeply as possible. Amalgam can then be tamped into the canal until it is tightly filled.

REPORT OF CASES

CASE 1.—A 35-year-old farmer consulted me in April, 1935, because of attacks of spasmodic lancinating pain in the right cheek and lower jaw, induced by eating, shaving, and other tactile stimuli to the area. He had had these attacks recurrently for several years, but for the past few months they had been more frequent and severer. He was highly nervous, had lost much weight, and was becoming increasingly unable to do his work, owing to his inability to eat or sleep. X-ray of the sinuses and skull was normal. The right infraorbital and the mandibular nerves were blocked with procaine. When anesthetized, the skin of the face could be strongly stimulated without inducing any trace of paroxysm.

The infraorbital nerve was injected with ethyl alcohol, and an attempt was made also to infiltrate the mandibular nerve. The patient returned in 2 weeks to report that the pain was gone in the infraorbital region but that the lower jaw was still having severe paroxysms from the angle of the mandible to the chin. It was decided that the decline in the patient's mental and physical condition justified an attempt to section the mandibular nerve as far back in the canal as possible, and the idea was conceived of introducing amalgam filling into the canal to prevent the reunion of the severed nerve ends. Complete anesthesia of the inferior dental nerve distribution was secured by the method described, and complete relief of the pain was immediate. The patient returned in August, 1935, four months after the alcohol injection, complaining that, while the lower jaw was still anesthetic and free from pain, the infraorbital area was regaining sensation and spasms of pain were recurring with increasing severity. It was proposed to carry out a procedure on the infraorbital nerve canal using the same technique of neurectomy and blockage with amalgam as had been successful on the nerve in the mandibular canal. This was done on Aug. 18, 1935. Recovery was uneventful, and complete relief was obtained from all manifestations of the tic. The patient was examined periodically for the next four years, when contact was lost in 1939. During that time there was no return of sensation or pain in either the infraorbital or the mandibular distribution, and the patient appeared to be cured of his tic.

CASE 2.—A 71-year-old housewife consulted me on Sept. 15, 1939, because of attacks of lancinating pain over her left cheek of several years' duration. The pain occurred on chewing, talking, or any external contact with the infraorbital area. It was spasmodic and caused her to cry out. She was debilitated and had lost a great deal of weight in the last month. X-ray examination showed no sinus or skull pathology. She was edentulous, and no dental roots were present. On Sept. 19, 1939, the left infraorbital nerve was evulsed from its canal and the latter plugged with amalgam. Complete anesthesia of the area supplied by the nerve and complete relief from the tic were obtained at once. A report from her on Aug. 6, 1955, states that she has had no sensation or pain in the area since the operation, 16 years ago. She is now 87.

CASE 3.—A 63-year-old merchant consulted me on Dec. 26, 1947, for treatment of paroxysmal pain over the left cheek. The attacks had been irregular, with remissions for various periods of time.

The left sphenopalatine ganglion was cocainized and the patient advised to see his dentist for a dental check-up. He was next seen on May 26, 1950, when he returned because of an increase in severity of the attacks of pain in his left cheek. He had had intermittent periods of pain for the past two and one-half years, but they were not severe enough to cause him to seek treatment. No nasal pathology was found. The sphenopalatine ganglion was cocainized again. He was given a heavy course of vitamin A both parenterally and orally. On Aug. 21 the paroxysms of pain were much severer and more frequent. One month later he was suffering continually with severe paroxysms over the left infraorbital nerve distribution. On Oct. 3, 1950, a neurectomy of the left infraorbital nerve and plugging of the canal with amalgam was done. Relief was immediate, and up to the present, almost five years after the operation, he has shown no return of sensation in the area and has had no tic. X-rays show the metallic plug in place in the foramen of the canal.

CASE 4.—A 64-year-old housewife presented herself on Nov. 4, 1953, with a diagnosis of trigeminal neuralgia of the left infraorbital nerve. For several months she had been having paroxysms of pain over the left cheek. Her teeth had been removed and the alveolar processes curretted. She had had prolonged courses of vitamins and antibiotics. She had been taking sedatives and codeine for three months and had been advised that an intracranial operation to cut the nerve might be necessary. She was in a state of extreme nervous exhaustion. X-ray examination showed no sinus or skull pathology and no dental roots. There was no evidence of any neuropathology. On Nov. 11, 1953, the left infraorbital nerve was sectioned and the canal plugged with amalgam. Relief of pain was immediate; recovery was uneventful, and examination on Aug. 10, 1955, one year and 9 months later, showed no return of sensation and the patient states that she has not had an attack of pain since the operation.

CASE 5.—A farmer aged 73 consulted me on Jan. 18, 1955, because of severe tic douloureux of the right infraorbital nerve of several years' duration. He had been examined in the university hospital of a neighboring state and had received thorough medical treatment as well as alcohol injections into the nerve, with relief for only a few weeks. He had been advised that a brain operation would be necessary if the pain recurred. The attacks were now becoming worse again, and he had become very discouraged with his situation. On Jan. 19, 1955, a neurectomy of the right infraorbital nerve was done and the foramen plugged with amalgam. He experienced immediate and complete relief from pain. In spite of postoperative pressure over the area, a hematoma formed, which necessitated aspiration on the third day. I attributed this complication to the congestion in the area caused by recent injection of alcohol into the tissues. Recovery was uneventful, and a report on Aug. 7, 1955, states that he has had no pain for the 7 months following the operation.

CASE 6.—A 69-year-old janitor was seen Nov. 9, 1953, with a typical paroxysmal neuralgia of the right mental nerve. The pain was distributed over the right side of the chin and the right lower lip and gums. The attacks were precipitated by eating, drinking, shaving, and similar stimuli. Examination showed no significant systemic disease. X-ray of the mandible showed no dental or bone pathology. He was partially relieved by medical treatment with vitamin B complex, Vitamin B_{12}, sedatives, and acetylsalicylic acid (Aspirin). He was treated at various times over a period of more than a year and was fairly comfortable. On Jan. 26, 1955, he was seized with a severe attack which did not respond to any medical treatment. On Jan. 27, he refused to eat, drink, or talk because of the excruciating pain induced. The right mental nerve was blocked with procaine and complete relief was secured for the duration of the anesthesia, after which the pain was as severe as ever. On Jan. 29, 1955, a neurectomy of the right mental nerve was done and the mental foramen plugged with amalgam, as described. There were a few twinges of pain on the first postoperative day, after which there was complete relief, which has continued to the time of this report, 6 months after the operation.

CASE 7.—A 69-year-old farmer was seen Dec. 3, 1954, giving a history of tic douloureux of the right infraorbital nerve and the frontal branch of the ophthalmic nerve of several years' duration. He had had both branches injected with alcohol repeatedly, and both branches had been resected through external skin excisions. Recurrence of pain had always followed all of these procedures. He had been advised that resection of the Gasserian ganglion root should be done. Because the infraorbital pain was severer than the frontal and because the patient was reluctant to submit to the intracranial operation, it was decided to give him as much relief as possible by sectioning the infraorbital nerve and plugging its canal. This was done on Feb. 24, 1955, and he still had anesthesia and freedom from tic in the infraorbital area 6 months later. The problem of returning pain above the eye remains.

COMMENT

There is probably no group of patients in medical history who have endured more prolonged and intense suffering than those af-

flicted with tic douloureux. Until recently, no entirely satisfactory cure has been offered them and the technique reported here is certainly not a cure in the best sense of the word.

In a larger series of cases there would undoubtedly be failures. However, if properly done, I do not believe that any uncomplicated case of peripheral neuralgia of either the infraorbital or the inferior dental branches will fail to have the trigger area permanently anesthetized by the use of this technique and I am confident that a very large percentage will secure permanent relief from their pain. In each of these cases the reaction has been one of extreme gratitude for being rescued from a seemingly intolerable situation. The relatively restricted area of numbness has been accepted as a small price to pay for the release from their painful tic.

SUMMARY

A method is described for the relief of tic douloureux of the second and third branches of the trigeminal nerve, by which the nerves are sectioned and the bony canals plugged with amalgam filling to prevent regrowth of the nerve fibers. Seven cases are reported in which the operation has been successful in completely stopping the pain. There were six operations on the infraorbital branch, one on the inferior dental branch within the mandibular canal, and one on the mental branch at the mental foramen.

Of the infraorbital operations the first was done 20 years ago, and there was no return of sensation or pain for a known period of 4 years after the operation, when contact with the patient was lost.

The second was done over 15 years ago, and there has been no return of symptoms to date. The third has almost 5 postoperative years; the fourth, 1 year and 9 months; the fifth, 7 months; the sixth, 6 months, and all are without recurrence.

The operation on the inferior dental branch in the mandibular canal was done 20 years ago, and there was no recurrence at the end of 4 years. The mental nerve operation has had 6 months postoperative observation, with no recurrence.

The results in this small series seem to justify the suggestion that uncomplicated cases of intractible peripheral trigeminal neuralgia involving the second or third branches of the fifth cranial nerve, without involvement of the first branch, be operated on by the method described before resort is had to central nervous system surgery. Many cases will be permanently relieved without the necessity of sectioning the Gasserian ganglion root.

A Liver Retractor for Cholecystectomies

JOSEPH WINSTEN, M.D., Baltimore

Proper exposure at the porta hepatis has always been considered an important safety factor in surgery of the biliary tract. The ability to visualize easily the vital structures in that region in most instances means the difference between a relatively easy procedure and a difficult one. The use of a Deaver retractor on both sides of the gall bladder extending down to the porta has usually sufficed to give adequate visualization. However, the difficulty of keeping both retractors in a constant position and the need for two assisting hands to hold these retractors are conditions that might be improved.

The retractor shown in Figure 1 obviates these objections by providing retracting blades that cannot move independently and by requiring only one assisting hand to retract on both sides of the gall bladder. In essence, the retractor utilizes two thin spring-metal blades attached above by a single shank and separated for most of their length by a space 5 cm. wide. In this way the tips of the retractor are free and maintain a fixed position in relation to each other. The hollow portion between the blades allows the gall bladder and ductal structures to lie free in the wound and be manipulated at will. The width of the upper portion of the face of the retractor is such that the liver edge is retracted out of the field for practically the length of the incision. Because of this width, the retractor functions to best advantage where a subcostal incision is made. In cer-

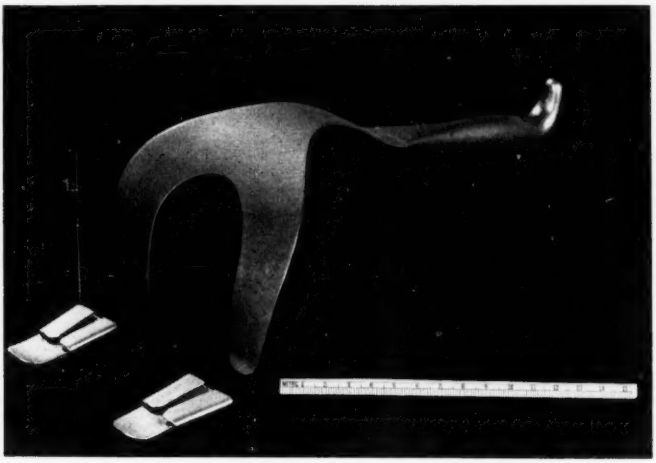

Fig. 1.—The liver retractor with its detachable extenders is shown here with a scale. Note that the distal tips of the retracting blades and the extenders are bent outward slightly to reduce the possibility of cutting through the liver capsule.

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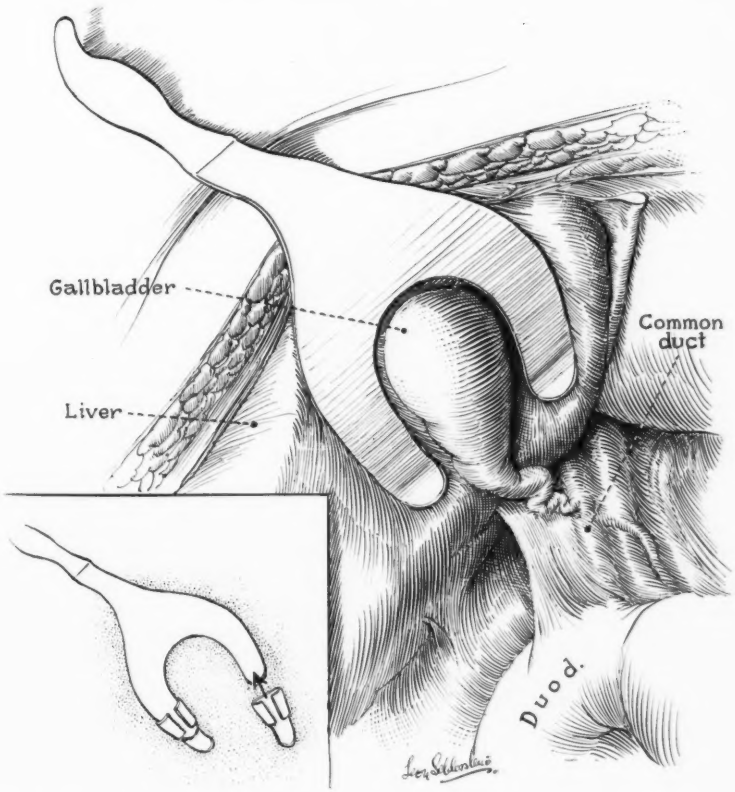

Fig. 2.—The retractor is pictured in its operative position. The insert shows how the extenders are attached to the blades.

tain cases, however, it can be used with a transverse or oblique incision.

Where the skin-to-porta distance is greater than usual, as in obese patients, the addition of the extenders to each blade increases the effective depth of retraction by 1.5 cm. If the gall bladder occupies an oblique position in relation to the liver edge, the use of an extender on the medial blade only will allow maximum retraction, even though the retractor in such a case would also be held obliquely (Fig. 2).

Trends in Orthopedic Surgery

FREDERICK R. THOMPSON, M.D., New York

THE CEREBRAL PALSY PATIENT

At a meeting of The American Academy of Orthopædic Surgeons, in Los Angeles, Jan. 29 to Feb. 3, 1955, Dr. Lenox D. Baker reviewed the need for surgery in the patients of the North Carolina Cerebral Palsy Hospital. He felt that somewhere between 16% and 27% of patients were suitable for surgery. The practice in this hospital had been to carry out the surgery as soon as possible in order that the child could be properly trained later. Dr. Baker's important review is at variance with many opinions from cerebral palsy centers, but it shows what can be done to rehabilitate the child when a center is controlled by a competent orthopedic surgeon with a large clinical and surgical background.

For the foot deformities it was considered paramount to obtain a stable platform on which the child could later walk. The equinus deformity lent itself well to the Vulpius procedure of calf-lengthening. The valgus flatfoot was frequently handled by the Brice talocalcaneal fusion, particularly when the talus was plantar-flexed and the foot everted from beneath the talus. Other flatfoot operations, such as the Miller operation combined with a naviculocuneiform arthrodesis, had been found of value.

For the flexed knee, the release of the origin of the gastrocnemius or the procedure devised by Green was recommended. Patella advancement was helpful in other cases. In those knees swinging into genu valgum, release of the iliotibial band, together with the gastrocnemius origin release, was of value. Mention was made of transplantation of the hamstring insertions into the lower end of the femur.

For hip contractures, the Yount release together with an obturator neurectomy had value in some, while in the severer cases a hip flexion release of the standard type was necessary, together with capsular division. For the internal rotation hip deformity, a release of the origin of the gluteus muscles from the ilium was preferred rather than the Durham procedure of dividing the anterior half of the gluteus medius insertion on the greater trochanter of the femur. In some hip flexion deformities a quadriceps origin release was advisable, and in others it was found necessary to divide the sartorius origin. Braces occasionally were necessary after surgery.

Dr. H. Relton McCarroll, in his discussion, brought out the fact that surgery on bedridden patients was not advisable, and he believed the patient should be able to balance or to walk before it was done. Dr. Baker, however, felt that many patients even though bedridden, could be made to walk, if proper surgery was performed in the beginning and adequate training was continued.

Dr. William R. Duncan, of Seattle, read a paper at the same meeting on the release of the rectus femoris origin in spastic paralysis. In former years he and his colleagues had tried advancement of the patella, osteotomy of the hip or lower femur, together with hip and knee capsular releases and biceps transplants. They had come to believe that the quadriceps was really not weak in the patients with knee flexion deformities. They found it pulled a load of approximately 28 lb. as opposed to the 18 lb. pull of the hamstring. They felt the primary problem was that of an alienated rectus, which needed to be divided to allow the hamstrings subsequently to relax. The advantages, Dr. Duncan

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claimed, were that a release of the rectus would permit the hip flexion to diminish with less coincident lordosis. He believed the operation would cause relaxation of the hamstrings and then decrease the flexion deformity of the knee. After operation the patients were noted to stand 2 to 4 in. taller than before the operation. He noted, too, a decrease in muscle tone of all the other muscles of the lower extremity on the operated side. He had not noticed any decrease in measured power of the quadriceps after the operation. Of 43 patients operated upon, 30 had had bilateral knee flexion deformities. Thirteen of these were markedly improved, four somewhat improved, and four slightly improved. There had been no patients who were not unchanged after the surgery, and none were made worse. Seven of the patients advanced themselves to another stage of motor development and were able to walk if they formerly had been confined to a chair or were able to sit in a chair if they had been confined to bed.

Dr. Walter E. Landmesser, of Ewington, Conn., demonstrated an opponens spacer, a small gadget made of a plastic which could be placed in the web between the thumb and the index finger to hold the thumb in the proper position for apposition against the more controlled fingers of a spastic child's hand. The appliance, fashioned by a technician at the hospital, was simply made and was ingenious in that it allowed some of the children actively to use a formerly useless hand. Its primary importance, although not advocated by the author, seemed to be in its use as a means of discovering the proper position in which later permanently to fix the thumb by means of a strut-graft between the first and second metacarpal bones. In the young child, however, it was a valuable aid to specialized training in the use of the hand.

SOME OBSERVATIONS ON EPIPHYSES

Dr. S. L. Haas, of San Francisco, reviewed some previous experiments of his in which various types of clinical devices were used about the epiphyseal cartilaginous plate in an endeavor to gain additional growth. Although some of the epiphyses seemed to increase in growth immediately after surgery, the final results were very disappointing. The direct injection of growth hormones into the blood supply of the epiphyseal plate was likewise a failure.

Dr. L. J. Strobino, of Utica, N. Y., reported on the effect of compression upon the growth of epiphyseal bone. This work, done in conjunction with Dr. Paul C. Colonna's Clinic, in Philadelphia, was carried out to determine the effect of compression on the rate of growth of long bones. Holstein calves were employed because of their pure breed and rapidity and magnitude of growth. Compression devices were inserted across the epiphyseal line of the upper tibia in 12 calves. These revealed that the rate of growth of bone was apparently normal almost up to the moment of the arrest level. The force necessary to cause cessation of growth was approximately equal to the weight of the animal across one epiphyseal line. A weaker force did not slow growth. This tended to show that growth complied with an all-or-none law. In one animal bone growth was arrested for seven months, and when the restricting force was released growth resumed at an accelerated rate until the involved tibia eventually equalized the normal in length and diameter. Strobino felt that 50 lb. per square inch stopped epiphyseal growth in the calf. It is unknown what force would be required in a human.

CORRECTION OF DISCREPANCIES OF GROWTH OF THE LOWER EXTREMITY

In Dr. William T. Green's clinic, in Boston, the staff had performed approximately 500 operations designed to inhibit growth, of which 375 were epiphysiodeses and approximately 100 were stapling procedures. The failures had been due chiefly to the epiphyses not being properly closed or to the opposite normal epiphysis failing to grow adequately as anticipated. The perplexing problem was the failure of the child to conform to the age group and type into

which he had been placed, and this frequently caused failure of the operation because the arrest had not been done early enough. He felt that staples were quite effective in stopping growth, but they had the disadvantage of necessitating more secondary operations. Their value lay in the fact that one could obtain some additional growth by withdrawing the staples if the arrest had been performed too early. He felt that there was a place for the two operations in orthopedic surgery. Although operation formerly had not been advocated before the age of 10, he believed that in many instances it should be done earlier if a large growth discrepancy was to be made up.

SPONDYLOLISTHESIS

Dr. David M. Bosworth, of New York, reviewed a consecutive series of lower lumbar spondylolistheses treated by spinal fusion during the period from 1928 to 1953. Although excision of the loose arch of the spondylolisthetic vertebra had been first performed by him in 1941, it was not routinely performed until two years later. This removal was always followed by a spine fusion. He noted that the vertebral body tended to slip forward approximately 20% before it became checked. He felt that the loose arch resting on the articular facet of the sacrum below served as a major factor in this check of the forward slip. Forward slip was checked because the ligaments holding the loose arch to the lamina of the vertebra above frequently remained intact and because the loose arch rotated cephalad and frequently came to underlie a portion of the lamina of the vertebra above. The author believed that simple removal of the arch without fusion was usually successful in relieving the patient of pain but might cause trouble in the future, owing to further slip. His figures of successful primary arthrodesis were 85%, and when the pseudoarthroses were repaired by subsequent operation a total solid and symptomless group of 92% was obtained. He noted that rarely was a herniated disc present at the spondylolisthesis level. He had not noted the osteocartilaginous material at the pedicle, as described by Gill, causing nerve-root pressure, but he showed slides of the material and suggested that some cartilaginous areas in the defect might heal by forming this type of tissue.

INTERNAL FIXATION IN DISPLACED INTRACAPSULAR FRACTURES OF THE HIP

In his discussion, Dr. George O. Eaton, of Baltimore, noted that the high incidence of nonunion of femoral neck fractures, which rarely is lower than 20%, may be due to improper imobilization of the fragment. He demonstrated that the usual Smith-Peterson type of nail, centrally placed, allowed a considerable movement of the fracture, which was less pronounced if the nail was driven lower in the femoral neck to impinge against the calcar. Even the low drive, however, has the disadvantage that the head of the nail is not immobilized, and for this reason he advised the use of a Jewett one-piece type of nail. The nail portion of the appliance should be anchored well in the calcar. Dr. Eaton had 18 consecutive cases treated by this method and all had united. He felt that efficient fixation appeared to be more important in securing union than exact reduction, and he noted the comparison between the high incidence of union in his cases properly immobilized and the carpal-navicular fracture which now seems to unite very well if adequately immobilized.

EFFECT OF ANTICOAGULATIVE SURGERY IN BONE REPAIR

The effect of anticoagulants on surgery was discussed at the Academy meeting by Dr. Frank E. Stinchfield. The widespread use of anticoagulants in the treatment of thrombophlebitis and pulmonary infarcts has been demonstrated to interfere with the healing of soft tissues. Experiments on rabbits and dogs, carried out by the author, were designed to see what effect the proper anticoagulant level would have on bone repair if the drug was given preoperatively, immediately postoperatively, or one week after operation. It was found that heparin

or bishydroxycoumarin (Dicumarol) given preoperatively at proper blood levels prevented the bone from healing and resulted in nonunion of a graft. If, however, the normal bone repair was allowed to progress for one week before the administration of the anticoagulants, bone healing, although inhibited, was not so greatly impaired that it would cause nonunion. This valuable work brings up the problem of the cautious use of anticoagulants in cases in which bone repair is necessary. There is every evidence to indicate that both of the above anticoagulants will prevent the formation of osteoblasts in the primary stages of bone repair, if either is present in sufficient quantity at a local cellular level of osteogenesis.

THORACIC SPINE DISCS

Dr. Edward B. Schlesinger, of the Neurological Institute of New York, in discussing the thoracic spine disc, called attention to the young age at which these discs are found. The condition is rather rare in older persons persons and is much more likely to occur between 16 and 25 years of age. There is very little normal motion present in the thoracic spine, and the most pronounced motion is due to severe injuries which, by hydrostatic pressure, forcefully extrude the disc posteriorly against the dura and cord. This causes severe damage to the cord as it is pressed against the lamina, so that at operation a black-and-blue spot is nearly always noticed on the dorsum of the dura, which has led some surgeons to believe they were dealing with an intradural tumor. If the extrusion and paralysis occur slowly, the patient is more likely to get well than if complete paralysis is instantaneous. The roentgenograms of most patients show definite bone changes in the form of a Schmorl node indentation of the inferior surface of the vertebra above and of the superior surface of the vertebra below. Frequently, calcification is present in the disc of that level, and, if one looks closely in the older, prolonged cases of paralysis, one can frequently see the calcified, herniated disc lying in the dural canal, overlapped by the shadow of the pedicle of the inferior involved vertebra. It is more characteristic to see these bone changes than not to see them, and many physicians have mistakenly diagnosed the paralysis as due to tuberculosis or have failed to diagnose the condition, thinking they were dealing with a case of Scheuermann's disease. Relief of the paralysis in many has been obtained by removal of the disc in long-standing cases.

SUPRACONDYLAR ELBOW FRACTURES IN CHILDREN

Supracondylar elbow fractures were discussed by Dr. Arthur Seifer, in Philadelphia, at a regional American College of Surgeons' meeting, with special reference to the problem of maintaining position of the fragment in the presence of embarrassed blood supply to the forearm. Adequate reduction of the fragments with maintenance in the fully flexed Jones position occasionally leads to shutting off the circulation to the forearm. With release of the flexed position, the fragments may displace themselves. Dr. Seifer has found it feasible to maintain the original adequate reduction by use of a heavy Kirschner wire passed through the capitellum while the elbow is in the fully flexed position. The wire passes upward to serve as an intramedullary nail. Usually one heavy Kirschner wire is sufficient, and the elbow may then be extended to a position of 150 degrees, allowing adequate return of circulation to the forearm. The wire may then be withdrawn two weeks later, without damage to the capitellum.

FRACTURED OS CALCIS

Dr. Barbara Stimson, of Poughkeepsie, N. Y., in reviewing the treatment of fractures of the os calcis, brought out the historical fact that Hippocrates treated these fractures by early mobility after the foot and calf had been bandaged and elevated. The ancients anticipated weight-bearing by the 60th day. Throughout the Middle Ages, fractures of the os calcis were treated in that fashion, and as late as the time of the first textbooks by Cotton and Scudder treatment was essentially by that method. It was not until the late 1920's that Key and Conwell first advocated

plaster fixation, and this type of treatment largely prevailed in this country until Carruthers, in 1951, again reverted to treatment with elevation and early motion. Although many compression fractures of the os calcis involving the articular surface need to be manually reduced by side-pressure and manipulation, so that the heel stays in the valgus position beneath the talus, they can be well treated by early mobility. Some surgeons prefer a plaster fixation for a few days until the soft tissues have gelled the fragments together. Early active motion, however, should be begun as soon as possible, thus avoiding the marked decalcification and prolonged convalescent period.

OSGOOD-SCHLATTER'S DISEASE

Drs. J. E. M. Thomson and C. Fred Ferciot, of Lincoln, Neb., discussed the surgical treatment of Osgood-Schlatter's disease. Their latest technique has been to excise the cartilaginous mass of the tubercle after splitting the patella tendon longitudinally and dissecting it free of the cartilage of the tubercle but maintaining its distal insertion into the thick periosteum covering the tibia. In a review of their total of 31 patients treated by various methods, they came to the conclusion that all methods stopped the pain, but that previous methods of drilling or pegging of the tubercle had resulted in the same unsightly bony enlargement as has always been present. Excising the tubercle does away with this cosmetic defect at the same time as it relieves symptoms. They found no difficulty with the operation and believe that the period of disability and immobilization was shorter than by other methods.

The dissection of the patella tendon from the cartilaginous mass of the tubercle is comparatively simple, and it is possible with an osteotome to remove this bulky tubercle, together with a portion of the tip of the tongue of the upper tibial epiphysis, without damaging the main epiphyseal plate. The tendon is brought together in the midline with a deep buried chromic suture. The skin incision should be placed lateral to the tibial tubercle in order to avoid the patella branches of the saphenous nerve supplying skin sensation to that area.

BENNETT'S FRACTURE OF THE FIRST METACARPAL BASE

The fracture of the first metacarpal base, originally described by the Irish surgeon Bennett, in 1821, has had various vogues of treatment ranging from simple abduction in a plaster gauntlet to traction fixation with a banjo type of splint. The end-results by most methods have usually been satisfactory from the functional standpoint, although there has nearly always resulted some permanent subluxation of the joint unless the original fracture was undisplaced. Most surgeons are beginning now to advocate early open reduction of the fragment, with either screw fixation or some type of wire fixation holding the joint from becoming subluxated.

16 East 90th St. (28).

Case Reports

ADRENAL HEMATOMA SIMULATING TUMOR IN A NEWBORN

Report of a Case and Review of the Literature

HECTOR M. MARIN, M.D.
JAMES H. GRAHAM, M.D.
and
CHARLES J. E. KICKHAM, M.D., Boston

ASPHYXIA at birth or trauma during and after delivery (prolonged labor, breech presentation, aggressive resuscitation maneuver, etc.) may precipitate adrenal hemorrhage in newborn infants. Local and general factors may facilitate this occurrence. The adrenal gland is large and extremely vascular at birth, and the inner cortex presents marked congestion with fatty and some necrotic changes.[1] Also, adrenal hemorrhage occurs more frequently between the second and the seventh postnatal days, when hypoprothrombinemia and increased vascular fragility are particularly pronounced.

Bilateral adrenal hemorrhage in the newborn infant is followed by a series of symptoms which have been well defined by Magnus [2] and by Goldzieher and Gordon.[3] Symptoms include those due to adrenal insufficiency and shock as well as hemorrhage within the gland (palpable retroperitoneal mass). If the hemorrhage is unilateral, symptoms of adrenal insufficiency and shock are less severe, and later, when the newborn infant recovers from the acute adrenal insufficiency, the appearance of a large abdominal mass may present baffling diagnostic problems. The following case report is illustrative.

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From the Departments of Pathology and Urology, Saint Elizabeth's Hospital.

Resident in Pathology, Saint Elizabeth's Hospital (Dr. Marin); Assistant Professor in Pathology, Boston University School of Medicine, and Pathologist, Saint Elizabeth's Hospital (Dr. Graham); Urologist-in-Chief, Saint Elizabeth's Hospital, and Assistant Clinical Professor of Urology, Tufts University School of Medicine (Dr. Kickham).

REPORT OF CASE

A 7 lb. 8 oz. girl was born on July 15, 1952, at full term. There was a difficult breech delivery following an uneventful pregnancy. The baby was born with asphyxiation and breathed only after long efforts at resuscitation. A few hours after birth an annular purple rash involving both knees and edema of the back were noted. There was a bluish-purple

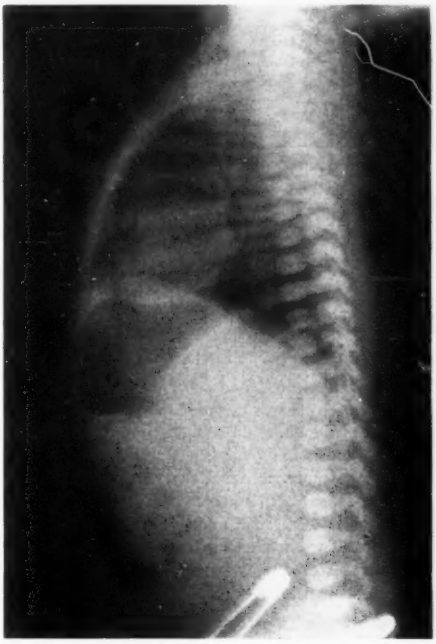


Fig. 1.—Flat plate of abdomen showing retroperitoneal mass displacing forward the stomach and ileal loops (lateral view).

mass below the right scapula, which on puncture exuded a sterile creamy matter. The general condition was otherwise satisfactory, and the baby was started on artificial feedings. Hemoglobin was 14.2 gm. per 100 cc.; red blood cell count was 4,510,000 and white blood cell count 8000 per cubic millimeter. Urine was negative.

Fig. 2.—Barium enema showing forward displacement of the splenic flexure of the colon (lateral view).

Three days after delivery the baby became rather abruptly cyanotic and somnolent, refused feedings, and did not respond to stimuli. There were no abnormal findings in the heart and lungs. Oxygen and penicillin were administered. Hemoglobin was found to be 7.4 gm. per 100 cc.; red blood cell count was 2,500,000 and white blood cell count 8500 per cubic millimeter. Urine was negative.

On the following day slight improvement was noted. Cyanosis had diminished, and the response to stimuli was more active. Roentgenologic examination of chest revealed no abnormalities. At that time, the fontanels were sunk and there were other signs of dehydration. Intravenous fluids and 70 cc. of blood were administered, with immediate improvement. At this time a firm, smooth, regular mass was palpated in the left lumbar area. It did not move on respiration. The mass persisted after an enema. Lateral view of the flat plate of the abdomen revealed the presence of a retroperitoneal mass displacing forward the stomach and ileal loops (Fig. 1). Barium enema showed no intrinsic abnormality of the large bowel, but the splenic flexure was displaced forward by the retroperitoneal mass (Fig. 2). No calcification or radiolucent areas were noted in the mass.

The baby's condition continued to improve during the following three weeks. She resumed normal feedings and gained 15 oz. The retroperitoneal mass, however, did not change in size or consistency. One month after birth hemoglobin was 13 gm. per 100 cc.; RBC 4,590,000, and WBC 10,000 per cubic millimeter. Urine was negative.

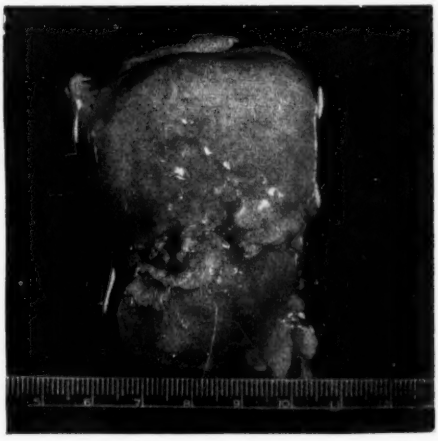
Intravenous pyelogram at this time visualized a normal right upper urinary tract. No dye was demonstrated on the left. A poorly defined soft tissue mass was noted in the flank, probably retroperitoneal, since gas-filled loops of bowel were displaced forward.

The presence of tumor, possibly a Wilms' embryoma, was suspected at this time and, on Aug. 22, an exploratory laparotomy was performed through an upper left rectus incision. Upon opening the peritoneum, a large firm mass which involved the upper pole of the left kidney was felt in the left renal region. The mass averaged about twice the size of a normal kidney and appeared *in situ* to be part of the kidney. The renal pedicle was ligated, and the mass was freed from the surrounding structures and removed.

Pathological Findings.—Specimen was a mass of tissue weighing 40 gm. and measuring 7×4×3 cm. (Fig. 3). On hemisection it was demonstrated to consist of a small kidney with superimposed rubbery mass that was larger than the kidney itself (Fig. 4). The covering was composed of a rather edematous chronically inflamed fatty tissue, making the line of demarcation between the kidney and the mass ill-defined. On section, a currant-jelly-like clot exuded from the mass, leaving a cystic cavity surrounded by brownish-to-yellow bordering material grossly resembling adrenal cortex. Cross sections of the kidney showed no pathology.

Microscopic Findings.—Microscopic examination showed normal kidney. The adrenal, for the most part, was replaced by blood clot. At the periphery of the clot there was considerable hemosiderin and

Fig. 3.—Specimen *in toto* (anterior view).



calcium deposition. Foreign-body giant cells were numerous. Some contained calcific debris, others small vacuoles and crystals. At the periphery a few aggregates of cells were arranged in cords and acini, representing the remaining cortex. Fibroblastic proliferation and lymphocytic infiltrate extended out into the surrounding tissue and fused the adrenal with the kidney. In areas, there was fresh fibroblastic proliferation into the clot.

Postoperative Course.—The postoperative course was characterized by progressive improvement. The baby gained weight and was discharged in good condition.

COMMENT

A review of the literature has revealed that only 11 cases of unilateral adrenal hematoma in the newborn infant have been reported (Table). Surgery was carried out in only two cases. In the case of Corcoran and Strauss,[4] clinical findings consisted in severe symptoms of intestinal obstruction and shock and the presence of a large mass occupying the entire left side of the abdomen, extending across the midline and down to the pelvis. Barium enema visualized an obstruction at the level of the splenic flexure of the colon. On operation a huge hematoma of the left adrenal compressing the colon was encountered, although details are lacking. The blood clot was removed, the bleeding vessel was ligated, and the baby recovered. In a similar case, reported by Emery and Zachary,[5] the infant presented transitory signs of shock. A mass was later palpated in the right flank, suggesting the presence of a tumor. At surgery the tumor was found by aspiration to be a large cyst filled with blood, which readily disintegrated during manipulations. Symptoms and findings in the 11 reported cases of this entity, as well as our personal case, follow a common recognizable pattern. A baby, born very often by breech or instrumental delivery, exhibits suddenly during the first four days of life symptoms of shock and adrenal insufficiency. He may become pale or cyanotic, vomit, or refuse feeding. High remittent fever and petechial rash may be present. The future course depends entirely on the status of the adrenal hemorrhage. If the hematoma ruptures and there is free bleeding, signs of peritoneal irritation

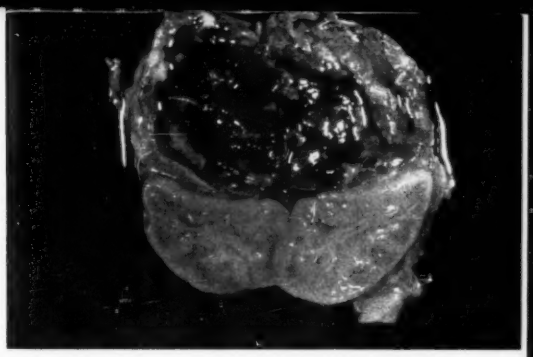


Fig. 4.—Appearance of the specimen after hemisection.

may appear (Cases 3, 6, and 7). If bleeding is not controlled, hypothermia, extreme somnolence, pallor, and coldness of the extremities will become apparent and the baby will die. More frequently, however, symptoms are much less severe. There are moderate pallor, slight fever or hypothermia, and occasional vomiting or anorexia which may be diagnosed as symptoms of mild infection or alimentary disorder, and the baby recovers. At this point, nevertheless, a large mass is palpable in the abdomen. The mass may be reabsorbed in a few weeks or remain unmodified. It may be entirely asymptomatic or may become clinically evident through a series of complications, such as pressure on the colon, compression, and distortion of the ureter (Cases 1, 10, and 12). When the hematoma does not rupture into the retroperitoneal space but gradually distends the capsule of the adrenal, it may cause enough inflammatory and fibroblastic reaction to produce apparent fusion of the mass with the kidney and, therefore, create the impression of a tumor growing within the kidney itself. It may particularly be confused with Wilms' tumor, which is described as "being round or lobulated and smooth and sharply demarcated from the compressed kidney by a band of connective tissues." [6] This impression may be confirmed by the radiological demonstration of a retroperitoneal mass displacing forward the splenic flexure of the colon as well as by the failure of the intravenous pyelogram to visualize the kidney and ureter. On the operating table the diagnosis can be easily made when the walls of the hematoma disintegrate under manipulation (Cases 1 and 10). If, as in the case described, enough time

Characteristic Features and Findings in Twelve Reported Cases of Neonatal Unilateral Adrenal Hematoma

Case No.	Author	Delivery	Age at Onset	General Symptoms	Palpable Tumor	X-Ray Findings	Complications	Treatment	Outcome
1	Corcoran and Strauss, 1924 [4]	Precipitated delivery	4 days	Fever, pallor, vomiting (fecal material), diarrhea	Present, lt. side	Barium enema: intestinal obstruction	Compression of colon	Surgical, removal of blood clot	Recovery
2	Goldzieher and Greenwald, 1928 [7]	Prolonged labor, low forceps	1½ days	Fever, pallor, cyanosis, convulsions, vomiting	Present, rt. side	Flat abdomen: negative	None	Transfusion, adrenal extract (Interrenin)	Recovery
3	Arnold, 1930 [8]	Normal (primipara)	4 days	Pallor, air hunger, twitchings	None; abdominal distention	None	Irreversible shock	None	Death; autopsy: ruptured rt. adrenal hematoma
4	Arnold, 1930 [8]	Normal	4 days	Pallor, listlessness	Present, rt. upper quadrant	None	None	Transfusion	Recovery
5	Arnold, 1930 [8]	Version and podalic extraction	3 days	Pallor, listlessness, anorexia	Present, rt. upper quadrant	None	None	Transfusion	Recovery
6	Arnold, 1930 [8]	Version and podalic extraction; resuscitation	3 days	Pallor, anorexia, rapid collapse	None; abdominal distention	None	Irreversible shock, hemoperitoneum	Transfusion	Death; autopsy: hematoma of rt. adrenal ruptured in peritoneal cavity
7	Goldzieher and Gordon, 1932 [3]	Normal	2 days	Cyanosis, pallor, tachypnea, fever	Present, rt. flank	None	None	Transfusion	Recovery
8	Goldzieher and Gordon, 1932 [3]	Resuscitation	1 day	Pallor, cyanosis, fever	Present, lt. flank	None	None	Intramuscular injections of blood	Recovery
9	Kohlbry and Wells, 1945 [9]	Low forceps	4½ hr.	Pallor, cyanosis, air hunger, vomiting	None; abdominal distention	Chest: negative	Irreversible shock, hemoperitoneum	Transfusion	Death; autopsy: ruptured hematoma rt. adrenal
10	Emery and Zachary, 1952 [5]	Forceps	2 days	Fever, pallor, listlessness	Present, rt. flank	I.V. pyelogram: displacement of kidney	Compression of kidney	Surgical, removal of blood clot	Recovery
11	Emery and Zachary, 1952 [5]	Normal (no medical care)	2 days	Pallor, soporous state, rapid collapse	?	None	Irreversible shock, hemoperitoneum	None	Death; autopsy: hematoma of rt. adrenal ruptured in peritoneal cavity
12	Marin and others, 1955 (present article)	Breech delivery	3 days	Pallor, cyanosis	Present, lt. flank	Barium enema: displacement of colon; I.V. pyelogram: no visualization of lt. kidney	Compression of kidney	Nephrectomy and adrenalectomy	Recovery

has elapsed since the occurrence of the hemorrhage to allow the formation of a fibrous capsule around the hematoma, the diagnosis becomes extremely difficult, as exploratory manipulation of the tumor mass in this area at the time of surgery must be avoided on the assumption that it may facilitate the spread of malignant cells.

The main interest of this syndrome lies in the fact that proper diagnosis prior to surgery may prevent the destruction and loss of a healthy kidney. It is hoped that the careful evaluation of the criteria above may help in the recognition of this syndrome in these patients.

CONCLUSIONS AND SUMMARY

A case of unilateral neonatal encapsulated adrenal hematoma simulating tumor and treated by nephrectomy is described. The salient findings in 11 cases previously reported in the literature are reviewed.

This syndrome has rather typical symptoms characterized by the appearance of a retroperitoneal mass shortly after a crisis, clinically consistent with mild adrenal insufficiency and shock. This mass may closely simulate a tumor of the kidney and in two recorded instances was considered to be a Wilms' embryoma. Diagnosis can be made only if symptoms referable to adrenal insufficiency and sudden appearance of a retroperitoneal mass are considered as part of the same clinical picture.

Dr. Mario Stefanini made helpful suggestions in the preparation of this paper.

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Notice

A. M. A. Annual Meeting, Chicago, June 11-15, 1956.—The 105th Annual Meeting of the American Medical Association will be held in Chicago, June 11-15, 1956, with a full program of lectures, television, motion pictures, and scientific exhibits.

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DIOSPYROBEZOAR IN THE POSTGASTRECTOMY STOMACH

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ROBERT L. MEANS, M.D.
and
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BEZOARS are relatively rare occurrences, and 73 to 90% of them are diospyrobezoars due to ingested unripened persimmons,* De Bakey and Ochsner [1] reviewed the literature most thoroughly, adding cases of their own, and showed that more than 70% of phytobezoars occurred after the age of 30 and that 77% were found in men. Chont [2] emphasized that children and Negroes are almost entirely immune to persimmon-bezoar formation.

Considerable speculation has revolved about the etiology of diospyrobezoar formation. It has been demonstrated that the pulp of the unripened persimmon fruit contains soluble shibuol, a phlobotannin, which under the influence of a weak mineral acid, such as hydrochloric acid, is converted into an adhesive coagulum cementing fragments of pulp, seeds, and peel together. As the fruit ripens, the shibuol is rendered insoluble so that coagulum formation is unlikely. It is the soluble shibuol which gives the unripened persimmon its astringent taste.

Japanese workers [3] incubated small fragments of persimmon in gastric juice and demonstrated the in vitro formation of a coagulum within a few hours. De Bakey and Ochsner [1] showed that, unlike other bezoars, persimmon bezoars, are encountered in patients with normal or high gastric acidity, but they expressed the opinion that the acid hypersecretion is secondary to mucosal irritation from the bezoar rather than etiological. Chont,[2] on the other hand, studied the literature and his own patients in whom gastric analysis had been carried out and showed that 92.4% of 26 patients had free hydrochloric acid. The remaining two patients, in whom no free acid was demonstrated, were his own patients, and he expressed some skepticism about the validity of the findings, suggesting that the free hydrochloric acid was neutralized by the bezoar. Chont also performed experiments with various parts of the persimmon fruit and various dilutions of hydrochloric acid and found that incompletely ripened persimmons formed bezoars in any solution of hydrochloric acid, with or without pepsin, but not in water or alkaline solutions. He appeared to be of the opinion that hydrochloric acid was necessary to the development of the persimmon bezoar.

The two in vitro studies described† demonstrated that the more concentrated the acid, the faster the chemical reaction, from which evidence it has been postulated that a person is much more liable to phytobezoar formation when the stomach is empty than when it contains food. This would account for the high incidence of persimmon bezoars in men, outdoor workers and sportsmen, such as farmers and hunters, who are rendered easy victims by their hearty appetite and empty stomach and the availability of poorly ripened fruit.

The presence of such foreign bodies in the stomach may lead to symptoms of acute abdomen or to chronic symptoms simulating peptic ulcer or carcinoma of the stomach. Furthermore, their presence causes mucosal irritation and complications, such as erosions, ulcerations, hemorrhage, perforation, and peritonitis.

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* References 1 and 2.

† References 2 and 3.

Fig. 1.—Mottled filling defects produced by presence of persimmon bezoar in the postgastrectomy stomach.

Recently, two cases were reported in which phytobezoars obstructed the small bowel after gastrectomy.[4]

A case is presented of diospyrobezoar formation in the gastric pouch associated with chronic gastritis and achlorhydria, following subtotal gastrectomy.

REPORT OF A CASE

A 59-year-old white male papermaker was admitted to the hospital Dec. 29, 1954, with a history of peptic ulcer complicated by perforation in 1944. In 1946, a subtotal gastrectomy had been carried out, and he had remained in good health until November, 1954, when he noted the onset of epigastric fulness, bloating, and soreness, without pain or radiation, occurring at the end of the evening meal, followed by nausea and vomiting of masticated food one hour after the meal. Shortly thereafter, he would experience a substernal burning pain which radiated upward to the hypopharyngeal region. The latter symptom would persist all night unless relieved by drinking milk or sucking lozenges. No other symptoms were elicited except anorexia, chronic constipation, and a weight loss of 10 lb. at the end of December. A history of persimmon ingestion over the past several years was established, although the patient adamantly maintained that he had never eaten the unripened fruit or its peel. No significant physical findings were noted. All laboratory studies were normal. A gastric analysis revealed no free hydrochloric acid after histamine stimulation and a maximum total acid of 23 units. Under fluoroscopy a barium swallow was seen to cascade about a roughly spherical mass in the base of the gastric remnant before forming a grossly irregular pattern reminiscent of retained food particles (Fig. 1). Further x-rays revealed a faintly outlined spherical mass rising above the level of barium (Fig. 2*A* and *B*). Esophagoscopy demonstrated a normal esophageal mucosa without evidence of erosion or inflammation. At gastroscopy, however, on passing the cardia, a roughly spherical mass was encountered, estimated to be about the size

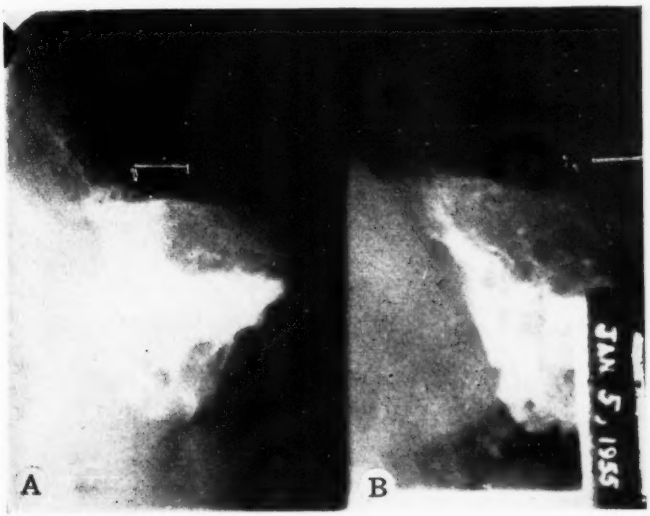

Fig. 2*A* and *B*.—Oblique views of the postgastrectomy stomach, showing protrusion of persimmon bezoar above the level of barium into the stomach bubble.

of a golf ball and covered by thick white mucus. The adjacent gastric mucosa had a beefy-red appearance with complete loss of high lights. A small segment of the stoma was visualized beyond the intragastric mass, but no further progress could be made in the passage of the gastroscope. On Jan. 12, 1955, an exploratory laparotomy was performed, and several soft masses were palpated within the

Fig. 3.—Fragments of persimmon bezoar removed from the gastric pouch.

fundus of the stomach. An anterior gastrostomy was made, and many irregular fragments of persimmon peeling were removed, weighing approximately 2 oz. (Fig. 3). The mucosa of the stomach was noted to be markedly hyperemic, dull, and friable, bleeding easily with minimal trauma.

The appearance of a bezoar after subtotal gastrectomy would tend to refute the belief that free hydrochloric acid is essential for its formation; however, we refrain from such a claim, feeling that subtotal gastrectomy is not an infallible means of rendering a patient achlorhydric and that the absence of free hydrochloric acid may well be an expression of the chronic gastritis encountered rather than the state which existed when the bezoar formed. It is suggested that this mechanism may have been responsible for the two achlorhydric cases described by Chont.[2]

SUMMARY

The clinical and experimental manifestations of persimmon bezoar formation are discussed, and a case is presented in whom the bezoar formed after subtotal gastrectomy.

The relationship of free hydrochloric acid to bezoar formation is discussed, with reference to the influence of chronic gastritis.

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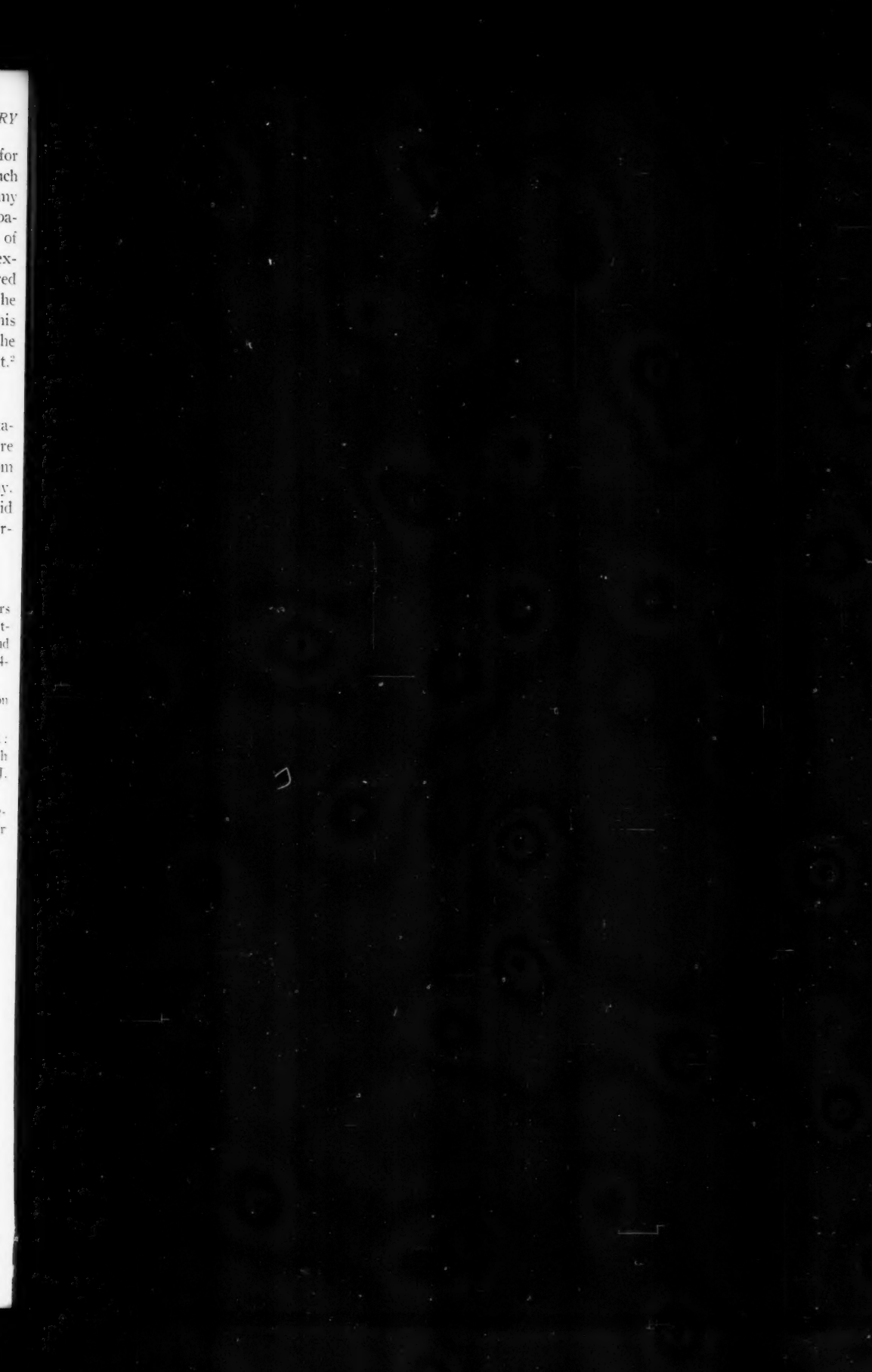
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